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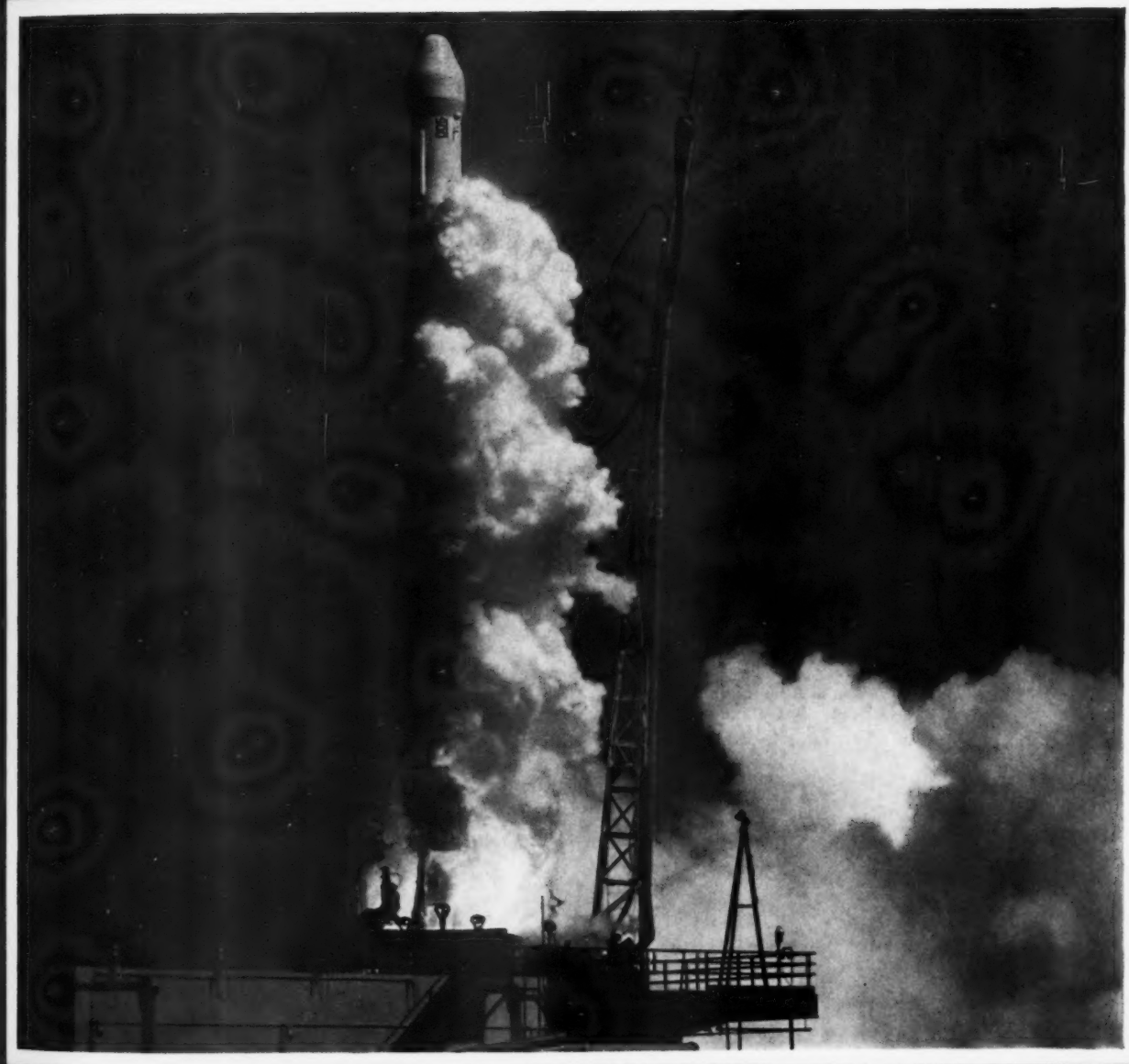

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LAUNCHING A COMMUNICATION SATELLITE

ARTIFICIAL satellites in orbit around the Earth may well revolutionize world communication. This month's cover illustration shows the Courier communication satellite being launched on a Thor–Able–Star missile. This satellite is described and its operation discussed on p. 504 in an article 'Courier communication satellite' by Messrs. Pierce W. Siglin and George Senn. The Foreword on p. 487 discusses 'Satellite communication'

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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SATELLITE COMMUNICATION

THE demonstration, within the last few years, of man's ability to put satellites into orbit around the Earth may well pave the way for a revolution in world communication. Such satellites would enable microwaves, i.e. radio waves in the spectrum between about 1000 and 10000 Mc/s, to be used for long-distance intercontinental and transoceanic communication. Microwaves are transmitted effectively over line-of-sight paths; satellites enable these paths to be extended to span distances of thousands of miles. Hitherto, only radio waves in the spectrum up to about 30 Mc/s could be used for such purposes; these radio waves depend in general on the ionosphere for transmission over long distances and as a result are of limited reliability and quality. Furthermore, the spectrum below 30 Mc/s is very congested, and there is little scope for new services.

The tests carried out across the United States and across the North Atlantic in 1960, using the balloon satellite Echo I, demonstrated that microwaves could be used successfully for long-distance communication; the received signals were closely in accord with theoretical predictions and free from ionospheric and other disturbances characteristic of radio waves below about 30 Mc/s. Although passive-reflector balloon satellites are simple devices, there is reason to believe that active satellites, i.e. satellites incorporating radio receiving and transmitting equipment, are to be preferred for high-capacity civil communication systems.

A valuable property of active satellite systems is the wide communication bandwidth—equivalent to several hundreds of telephone channels or a television channel—that could be transmitted on each radio carrier. Moreover, there is reason to believe that the transmission quality and reliability could conform with the high standards needed for international use. Another feature of great value for a world-wide network would be the ability of each satellite to provide communication between several stations simultaneously over a large area of the Earth's surface.

In these respects satellite systems differ from submarine repeatered cables, which are essentially a point-to-point transmission medium. At the present stage of development, long-distance submarine cables are suitable for about 100 telephone circuits, and the bandwidth is insufficient for television; however, designs of cable system now under development may enable this bandwidth to be increased.

Several countries are devoting a great deal of study and research to the development of satellite communication. There are many problems, including the type of satellite system that might best be employed, the design of ground stations and satellites, the frequencies to be used, and the organization of a world-wide network using satellites. Then, too, there are very important questions of finance and the related questions of the volume of traffic that would be carried by satellites. While one can be confident that these problems will be solved, there must be uncertainties about the way and the pace at which the situation will develop. To mention one thing only—and this can be put only in the form of a question—will there be one world-wide system owned in partnership by several countries, or will there be more than one system separately owned and controlled?

There are many technical problems to be solved, e.g. the more sophisticated systems involve satellite station-keeping and attitude stabilization, the former being used to keep the number of satellites to a minimum and the latter to enable directional aerials to be used on the satellites, thereby economizing in the satellite transmitter power required. Both are highly desirable provided that reliability and long life are not impaired. The modulation techniques employed should provide the most practicable compromise between the satellite transmitter power needed for a given over-all signal/noise ratio and the

r.f. bandwidth occupied; the modulation technique should also take into account the need for multi-station operation referred to earlier, i.e. the facility whereby satellite circuit capacity can be subdivided among several ground stations.

The large distances involved in satellite systems raise the question of the transmission delay and its acceptability for normal public telephony. This problem is specially important in the case of the synchronous orbit at 22000 miles height, where one-way delay over the satellite link is about 0·3sec. Delays of this magnitude may cause difficulties in conversation when such a satellite link is extended by long land-lines or when two such links are connected in tandem.

It seems clear that in this rapidly developing field we should proceed on a step-by-step basis, beginning with the launching and testing of experimental communication satellites and going on to the next step of testing experimental pilot schemes. For that reason, everyone will welcome the plan under which the United Kingdom, France and the Federal Republic of Germany will be co-operating with the American National Aeronautics and Space Administration in tests of satellite communication across the North Atlantic, beginning in 1962. For the purpose of these tests the United Kingdom will be providing an experimental ground station equipped with an 85ft-aperture steerable aerial system; this is being constructed on a site at The Lizard in Cornwall.

The range of frequencies suitable for satellite communication systems is determined by a number of technical considerations, and the choice of frequencies within this range must be acceptable nationally. It is also essential that international agreement should be reached if satellite communication is to be operated without mutual interference, or interference to and from other radio services.

This is a matter that is being examined by Study Group IV of the International Radio Consultative Committee of the International Telecommunication Union, which is to hold an interim meeting early in 1962 in the United States, in preparation for the Xth Plenary Assembly of the C.C.I.R. in 1963. The recommendations that may be made by that plenary assembly will be of special importance in view of the proposal to hold, later in 1963, an Extraordinary Administrative Conference of the International Telecommunication Union to consider space systems.

Satellite communication presents both a challenge and a stimulus to communication engineers and to their colleagues in the rocket-launcher and satellite-development fields.

As pointed out earlier, there are many technical, operational, and international problems to be solved, but the rewards of a successful outcome, both to world communication and to international co-operation, could be great.

THE RADIO RESEARCH STATION 1960

The Radio Research Station, Ditton Park, Slough, was reorienting its work in 1960 so that about 50% of the effort would be applied to problems associated with space research. This is made clear in the recently published 'Radio research 1960' (H.M.S.O., 1961, price 2s. 6d.) and is in accordance with the recommendation of the Council for Scientific and Industrial Research.

The emphasis in this space-research work moved towards the study of fundamental geophysical problems. This was made possible by the advent of space vehicles.

The number of observations of signals from artificial Earth-satellites increased greatly in 1960. More effort was devoted to the study and interpretation of the results. This was particularly so in the study of orbital perturbations and signal characteristics such as Doppler frequency shifts and Faraday-rotation effects.

Progress was made in the erection of radio interferometers for tracking purposes. A minitrack station was installed at Winkfield, Berkshire, in collaboration with the American National Aeronautics and Space Administration (see February 1961 *Journal*, p. 80).

Collaboration continued with Canada and the United States in investigations of the ionosphere from above, by means of satellites in orbit at the appropriate heights ('top-side' sounding experiments).

New information on the behaviour of the ionosphere at high latitudes, on ionospheric indices, on electron distributions, on the effect of artificial disturbances and on the winter anomaly in absorption was obtained in 1960. Long-distance transmission experiments, designed for the detailed investigation of the way in which h.f. waves are propagated via the ionosphere, continued.

Research on the propagation of v.h.f. radio waves through the troposphere involved further studies of scatter propagation to points well beyond the horizon at one extreme and, at the other, an examination of multipath phenomena on a short microwave line-of-sight link. The direct study of the refractive-index structure of the lower atmosphere was an important feature of the work. Further research was concerned with an attempt to correlate propagation characteristics with meteorological conditions on a synoptic scale.

Studies of atmospheric radio noise based on data obtained during the International Geophysical Year continued in 1960. Further studies of local lightning flashes were made. For assessing the interference of man-made noise at a given receiving location, experimental studies of this kind of noise in the v.h.f. and u.h.f. bands were undertaken.

Further research was carried out on microwave power measurement and on the standardization of strong electromagnetic fields at ultra-high frequencies.

MINE WINDING EQUIPMENT

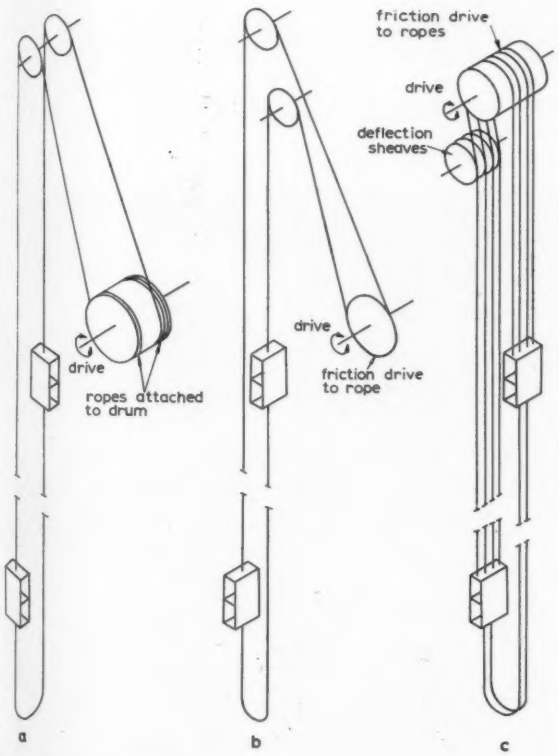
621.34:622.673

This article describes the winding systems employed in the United Kingdom and outlines the reasons for the adoption of multi-rope friction winders during the past decade.

The author is with the National Coal Board.

C. D. WILKINSON, MEMBER

More than 60% of the winding engines in Britain are electrically driven, and the replacement or conversion of steam winders is still proceeding. Many collieries are connected to the public-supply networks, and these are of sufficient capacity to withstand the peak loads imposed by the winding cycle without the need for load equalization. The Ilgner system, with its attendant flywheel, is not therefore called for in new installations, but graded acceleration of the winder motor is provided so as to reduce the peaks in the cycle. The horse-power range is wide and varies from a.c. winders of less than 100 bhp to multi-motored d.c. machines of 9000 bhp.



1 *Different types of winder*
a drum winder, with balance rope
b single-rope friction winder
c multi-rope friction winder

Drum winders

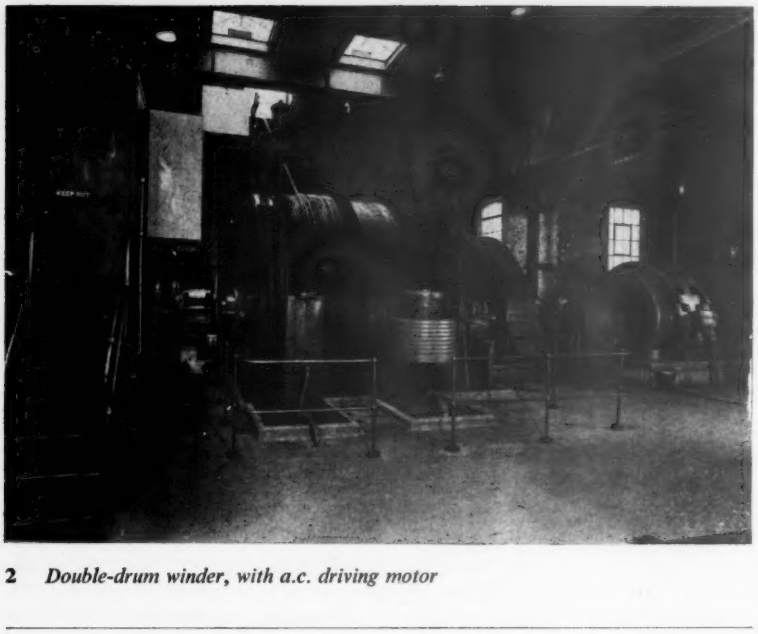
The traditional British drum winder is used wherever possible, but the necessity for increased pay-loads and the exploitation of deeper seams have renewed interest in the friction winder, known on the Continent as the Koepe winder, and since the Second World War 58 have been commissioned and a further 31 are on order or in process of installation.

The drum winder, Fig. 1a, has two separate winding ropes, one end of each being secured to the drum and the other to the cage or skip. One rope is wound onto the top of the drum as the other is paid off the bottom, or vice versa. The steel winding ropes are of locked-coil or multi-strand construction, and to limit the bending stresses in the ropes the ratio of drum to rope diameter is normally about 100: 1. Rigid or wire-rope cage guides may be used, and in order to reduce the peak load at the start of a wind and to assist braking at the end of it, a balance rope (or ropes) equal in weight to the winding rope is generally fitted.

Multi-level winding

Where mineral has to be wound from more than one level, the double-drum winder or the cage and counterweight system of winding may be used. Double-drum winders (Fig. 2) have two parallel drums, one keyed to the shaft while the other is loose and is driven through a multi-toothed clutch. Special interlocks are provided to ensure that, when the ropes have to be adjusted to wind from a different level, the brake must be applied to this loose drum before it can be declutched.

A disadvantage of the double-drum winder is that, except in special circumstances, a balance rope cannot be used. The cage and counterweight system provides a flexible alternative to the clutched-drum winder for multi-level working, and, although this system is normally associated with the friction winder, it has been successfully applied to conventional drum winders.



2 *Double-drum winder, with a.c. driving motor*

sharing of the load by a number of small ropes in parallel makes possible the use of a comparatively small high-speed friction pulley that possesses little inertia and which, by virtue of its small circumference, permits the use of a directly coupled motor of reasonable speed and frame size.

Each rope must carry its correct share of the total suspended load, but elaborate equalizing devices are not required, as experience has shown that, if the initial rope tensions are equal and the rope grooves are maintained uniform in diameter, the ropes are self-regulating and load sharing is automatic. In order to check this and to carry out any necessary adjustments, load indicators and adjustable links are incorporated in the suspension gear between the rope capels and the conveyances, as shown in Fig. 3.

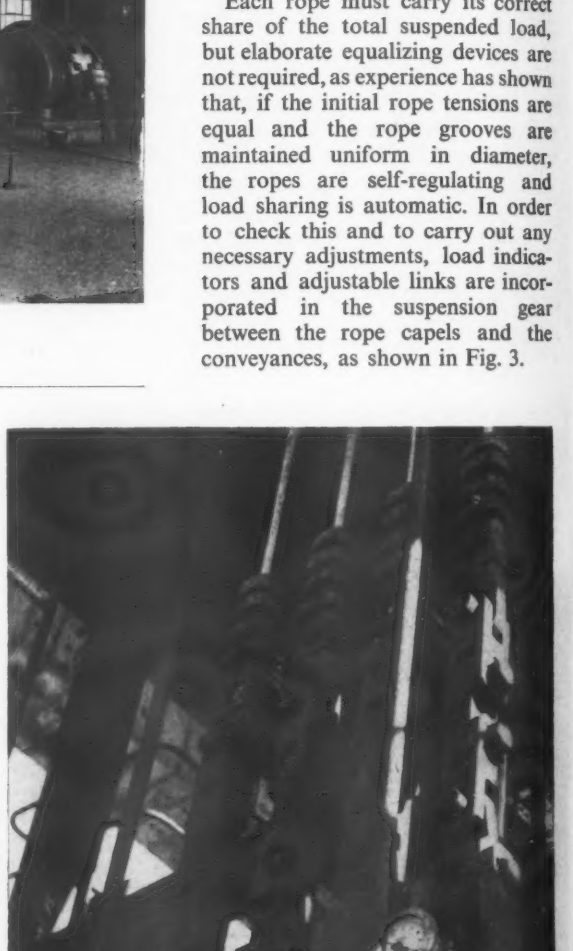
Friction winders

In order to obtain economical outputs from the deeper seams, pay-loads up to 20 tons have to be wound, and to cater for such a duty long winding ropes of large diameter are required. If drum winding is retained, the drums will be so large and heavy that the energy expended in their acceleration and retardation will be excessive and rope-fleeting difficulties may be encountered. The friction winder provides a satisfactory alternative, and in this system the heavy drum is replaced by a comparatively light friction pulley that has little inertia.

In its simplest form, Fig. 1b, the friction winder has only one winding rope, each end of which is attached to one of the cages or skips, the rope being in contact with only part of the circumference of the friction pulley. The cages are raised and lowered by the friction between the rope and the tread of the pulley, the latter being lined with a material that has a high coefficient of friction and that is capable of withstanding tread pressures between 250 and 300 lb/in.[2]

The coefficient of friction used as the basis of design is 0·2, and, in order to guard against rope slip, special attention has to be paid to the relation between the tensions in the winding rope on each side of the friction pulley. The use of a balance rope is essential with all friction winders.

Experience has shown that a locked-coil rope of about 2¼ in. diameter is the largest that can be constructed to have a predictable performance and an economic life. Ropes of this size will not always give an adequate factor of safety for hoisting from the deeper seams or dealing with heavy payloads, and to meet such conditions it is necessary to adopt multi-rope winding (Fig. 1c). The



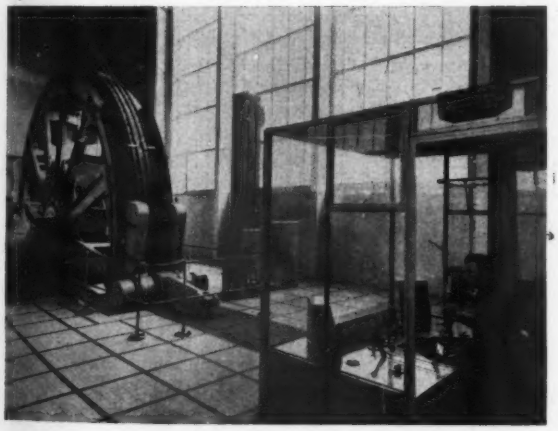
3 *Load indicators and adjustable links between winding ropes and cages*

Single-rope and twin-rope friction winders may be located at ground level (Fig. 4) or mounted directly above the mine shaft in steel or reinforced-concrete towers. Multi-rope winders are always tower mounted (Fig. 5) and most of them have rope-deflection sheaves fitted just below the friction pulley to increase the arc of contact between rope and pulley and to bring the ropes to the correct centres for the cages or skips. There is little difference in the cost of steel and of reinforced-concrete towers, and the choice is therefore largely dependent on local circumstances.

Gears and brakes

Directly coupled motors, with overhung armatures, provide a simple 2-bearing winding engine that gives the best possible mechanical arrangement and one that is particularly suitable for tower mounting, but, unfortunately, the high cost of large, low-speed d.c. motors often precludes the adoption of this desirable combination. Conventional reduction gears are generally used for ground-mounted winders, but the reduction gears used for tower-mounted winders incorporate a quill drive, or a gear-type flexible coupling, or a combination of both.

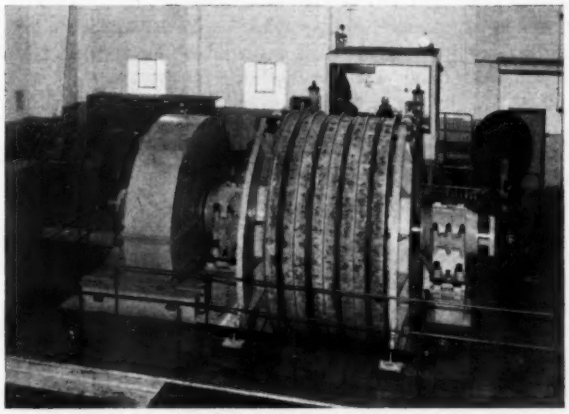
Brakes are of the block type, acting on a brake path that forms part of the drum or friction pulley. Results obtained from small-scale trials of disc brakes have not indicated that they have outstanding advantages, but their possibilities may be further explored. Dead-weight brakes are being superseded by spring brakes in which



4 *Twin-rope ground-mounted friction winder*

the shoes are applied by powerful pre-compressed compound springs and are held off by the pneumatic or hydraulic pressure in the operating cylinders.

The braking torque is varied by regulating the pressure of the operating medium, which, in hydraulically controlled brakes, is between 0 and 5000 lb/in.^{2} The control valve is so designed that the braking torque produced is proportional to the movement of the driver's brake lever. Rates of retardation are limited to values that will not initiate rope slip on a friction winder or cause danger or discomfort to personnel riding in the cages of a drum winder.



5 *2500 bhp 4-rope friction winder located 138 ft above ground level in a concrete tower*

A.C. winders have dynamic braking in addition to mechanical braking, and regenerative braking is an inherent feature of d.c. winders. In assessing the maximum permissible rates of retardation it is therefore essential to bear in mind the possible cumulative effect of mechanical and electrical braking.

A.C. and d.c. winders

No hard and fast rules govern the choice of the electrical system, and among the factors to be considered in deciding whether to use an a.c. or d.c. driving motor are the winding depth, pay-load, whether skips or cages are to be used, the desired accuracy of control, the civil engineering costs, whether the duty is continuous or intermittent, etc. The final assessment is made from the economic viewpoint, taking into account the capital charges and the running costs, and, unless there are special overriding considerations, the type of winder selected is that showing the lowest annual charge.

The simplicity and low capital cost of the a.c. winder have led to its widespread adoption, and, used in conjunction with dynamic braking, it is suitable for most winding duties. The motors are usually designed to work at the voltage of the incoming supply, as this makes it unnecessary to provide step-down-transformer capacity for them and so saves expense. The normal operating voltages are 3300, 6600 and 11 000V. Speed regulation is effected by metallic resistors or liquid controllers, the latter having the advantage that they give smoother

acceleration and are less likely to set up oscillation of the winding ropes. Manual control is most widely used, supervisory control of the winding cycle being afforded by cams or other means.

Closed-loop control has been tried on a number of a.c. winders but does not give an accuracy comparable to that obtainable with the Ward Leonard system, and, as it is expensive, its use on a.c. machines is at present confined to manually controlled winders where there are no complicated decking sequences or to automatic or semi-automatic winders operated by pushbuttons.

The d.c. motor used in conjunction with the Ward Leonard system and closed-loop control provides the most effective, if not always the most economic, method of controlling a mine winder, and the development of rotary and static amplifiers has made marked improvements in the accuracy of control. Synchronous motors are now used for driving the Ward Leonard motor-generator set, and as the power factor of the driving motor can be maintained constant, irrespective of the load on the winder motor, the kilovoltampere demand of the colliery is reduced.

The cost of the civil works associated with a motor-generator set is high, and in a number of multi-rope friction-winder installations economies have been made by placing the motor-generator sets in the winder tower. Most d.c. winders work between plus and minus 650 V, but in the most recent installations the range is between plus and minus 1000 V.

Rectifier winders

The high capital cost of heavy rotary machines and the standby loss and maintenance charges associated with their operation have led to the adoption of the mercury-arc convertor as an alternative to the motor-generator. In the normal winding cycle, there are periods when the load on the winder drives the d.c. motor as a generator, and if the d.c. supply is derived from rectifiers they are so arranged that in these conditions they act as inverters and return power to the supply system.

The figure-8 connection of the rectifier units gives a smooth transition from rectification to inversion but calls for two sets of rectifiers and transformers, and in order to keep down the cost the figure-0 connection is used for winder application. This halves the number of rectifiers required but calls for either field or armature reversal when the change from rectification to inversion takes place. During this changeover, electrical control of the winder is lost for up to 1 sec; although armature reversal would reduce this dead time, it creates switching problems, and, with two exceptions, all the rectifier winders so far commissioned or ordered are arranged for field reversal; field forcing is employed to keep the dead time to a minimum.

The use of 400 c/s magnetic amplifiers has improved control, and consideration is being given to the use of transistors to effect further improvements.

Difficulties arising from harmonics and low power factor have not proved serious, but experience has shown that surge diverters must be fitted to the transformers to prevent failures due to voltage rise if current chopping occurs.

The rectifiers and transformers for tower-mounted friction winders are housed in the tower, and a non-flammable coolant is used in the transformers to obviate the risk of burning oil falling down the mine shaft in case of fire.

Safety devices

The engine-man's controller for a drum winder or ground-mounted friction winder is located in the winding-engine house, but that for a tower-mounted winder may be either in the engine house at the deflection-sheave level or at ground level. Fig. 6 shows a winder-control station located at ground level, from which it is also possible to operate the pneumatic rams and safety gates. A number of semi-automatic winders are controlled by pushbutton when mineral winding, and one skip-winding

6 *Winding-control station, incorporating control of the cage-loading rams*

installation is fully automatic, but lever control is retained in all cases for winding men.

Protection against overspeed and overtravel is a statutory obligation, and there are several proprietary devices that afford such protection and also incorporate differential-speed control for man and mineral winding. Limit switches or proximity switches provide additional safeguards against overtravel, and, in friction winders, cage-arresting devices are fitted in the head-frame and sump. Arresters cannot be used with drum winders, and here the final safeguards in the event of an overwind are the rope-detaching hooks and head-frame catches.

Cage-position indicators must be provided, and they are usually driven from the main drum or friction-pulley shaft through the same train of gears that drives the overwind-prevention device. The ropes of a drum winder are securely attached to the drum and therefore the indicator always shows the correct position of the cage, but this is not necessarily so with a friction winder. Rope slip does not normally take place, but the variation of tension in the winding ropes as they pass from one side of the driving pulley to the other results in rope creep, and this can give rise to a false indication of the cage position and to errors in the setting of the overwind-prevention equipment.

Rope creep tends to be cancelled out if equal loads are wound in each conveyance in turn, but a certain amount of cumulative creep is unavoidable. Creep-compensating devices are therefore fitted to friction winders, and they automatically adjust the position of the control cams, cage-position indicator and overwind-prevention gear at the end of each wind.

Acknowledgments

The author wishes to thank the National Coal Board for permission to publish this article and to make it clear that the views expressed are personal ones and not necessarily those of the Board.

Summary

Much has been done in recent years to improve the performance and control of electric winding equipment, but there are still problems to be resolved. An improvement in the power factor of the mercury-arc convertor and a reduction in the time taken for the change from rectification to inversion would encourage the more widespread use of this type of equipment. The advances made in the manufacture of semiconductors indicates that the use of silicon rectifiers for supplying the winding load is a distinct possibility.

Improvements in closed-loop control may be expected, and the development of satisfactory static switching devices should limit the use of contactors and reduce maintenance. Accurate landing of the cages or skips and the reduction of creeping time in automatic winding systems are urgently required, and more positive indication of cage position is desirable, particularly for friction winders.

NEW CREEP LABORATORY

THE Electrical Research Association opened its new creep of steel laboratory at Leatherhead, Surrey, on the 6th July 1961. Measurements are made, in this laboratory, of the creep and rupture properties of high-temperature steels used in modern thermal power stations. The creep tests last for about 20000h or more.

The laboratory is equipped with 50 high-sensitivity creep machines fitted with optical extensometers, 50 dual-purpose machines for either dial-gauge creep or 3-specimen multi-rupture measurements, 50 10-specimen rupture machines and one 15ton creep machine. In addition, 11 rigs have been installed to test tubes stressed by internal steam pressure while at high temperature.

The high-sensitivity machines are in general used to measure the creep properties of rotor forgings. Half the dual-purpose machines are fitted with dial-gauge extensometers and are used for measuring the creep properties of castings employed for turbine cases. The other half and the 10-specimen machines are used for testing the rupture properties of steel for steam pipes and superheater tubes.

Electronic temperature controllers are used for controlling the temperature of the test specimens. The furnace temperature is about 650°C. The variation allowed is not more than 3°C.

The creep work is complementary to that undertaken by the steel-makers and provides an independent evaluation for the electrical industry.

IMPROVED B.B.C. FACILITIES

THE British Broadcasting Corporation announce that the new television station to serve the Morecambe Bay area will be built at Stewnor Park, some six miles to the north of Barrow. A contract has been placed for a 250ft mast to carry the aerials.

This is one of several new transmitting stations that the B.B.C. are building to extend and improve the coverage of their television service. It will bring improved reception to an area with a population of nearly ¼-million.

The Morecambe Bay station will get its programmes by radio link from a receiving station that will be built at Walthwaite, about one mile to the south-east, where the programmes will be picked up from the B.B.C.'s television station at Holme Moss.

It is expected that the new station will be ready for service during the summer of 1962. The transmissions will be on Channel 3 (vision 56·75Mc/s, sound 53·25Mc/s) with horizontal polarization.

The B.B.C. have also placed a contract for the supply and erection of a 750ft mast to carry the aerials of the new South-East Scotland television and v.h.f. sound station that is to be built at Dryden Hill, midway between Selkirk and Hawick.

The South-East Scotland station will serve an area with a population of nearly 100000 people, some 70000 of whom have not hitherto been within range of the B.B.C. television or v.h.f. sound service. It is expected that the station will be completed by the autumn of 1962.

THE PRESENT STATUS OF COLOUR TELEVISION

621.397.132

It has been known since the time of Sir Isaac Newton that, if spectrum colours are mixed in different proportions, mixture colours are produced that cover a wide gamut.

Exactly 100 years ago Clerk Maxwell demonstrated the reproduction of a scene in colour by the superimposition of the images of three lantern slides in the three additive primary colours, red, green and blue. Modern television-projection displays for simultaneous colour reproduction adopt the same technique.

This article is based on an informal lecture 'Recent developments in colour television', given by the author at a Hull District Meeting.

The author is with Electric and Musical Industries Ltd.

I. J. P. JAMES, B.SC., MEMBER

LARGE-screen colour-television displays are now available from several manufacturers with screens ranging in size from $6 \times 4\frac{1}{2}$ft to 12×9ft. These use three cathode-ray tubes, with Schmidt optical systems, to project the pictures from the front of the auditorium to the screen. Peak brightnesses of about 10ft-L are normally attainable when a screen with a gain of two is used. The same principle of colour synthesis by additive mixing of the three primary colours is employed in all practical colour-television receivers of today.

The signals required to control the intensity of light from the three coloured phosphors are derived in the simultaneous system from three camera pick-up tubes, in front of which are placed respective red, green and blue colour-selective filters and suitable beam-splitting optical systems, so that each tube views the same scene. If the over-all output/input characteristic of the system is linear, the light output corresponds in colour to that of the original scene, with a proportional brightness.

For closed-circuit operation it is sufficient to use normal scanning standards, which, with the 405 line 50 fields/sec interlaced 2 : 1 system, imply a bandwidth for each of the signals of 3Mc/s. For broadcast systems this bandwidth is much too wasteful; however, in January 1954, permission was granted to television stations in the United States to transmit the complete colour signal in a standard monochrome bandwidth.

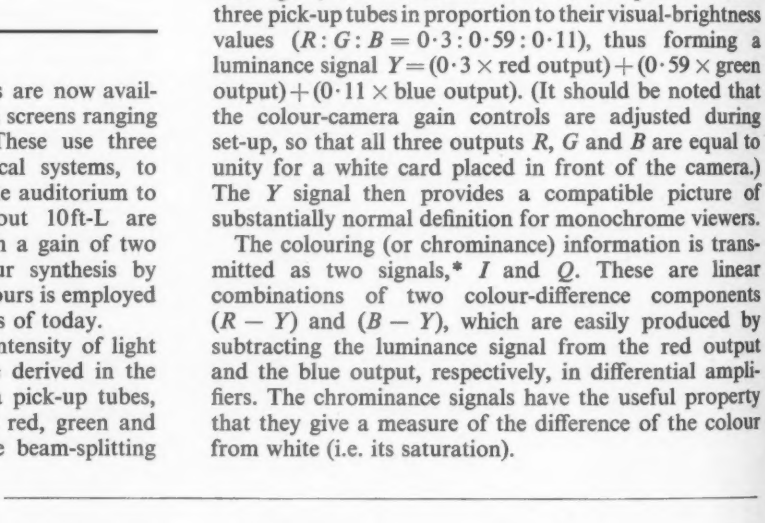
The method of achieving this—which is called the N.T.S.C. system after its designers, the National Television System Committee—is extremely ingenious, and, to date, no practical alternative system has been suggested that departs greatly from the same basic principles.

The N.T.S.C. system

In the N.T.S.C. system the problem of transmitting three signals via a common channel of normal monochrome bandwidth is solved by the realization that the eye of the viewer will accept a narrower bandwidth for the colouring information than for brightness information (acuity matching).

Since a monochrome receiver operates from a brightness signal, it is convenient to mix the outputs from the three pick-up tubes in proportion to their visual-brightness values ($R : G : B = 0{\cdot}3 : 0{\cdot}59 : 0{\cdot}11$), thus forming a luminance signal $Y = (0{\cdot}3 \times \text{red output}) + (0{\cdot}59 \times \text{green output}) + (0{\cdot}11 \times \text{blue output})$. (It should be noted that the colour-camera gain controls are adjusted during set-up, so that all three outputs R, G and B are equal to unity for a white card placed in front of the camera.) The Y signal then provides a compatible picture of substantially normal definition for monochrome viewers.

The colouring (or chrominance) information is transmitted as two signals,* I and Q. These are linear combinations of two colour-difference components $(R - Y)$ and $(B - Y)$, which are easily produced by subtracting the luminance signal from the red output and the blue output, respectively, in differential amplifiers. The chrominance signals have the useful property that they give a measure of the difference of the colour from white (i.e. its saturation).



1 *Schematic of the SECAM receiver delay-storage principle*

Since the eye is not so critical of colour detail as it is of brightness detail, the bandwidths of the colour

* $I = -0{\cdot}27\,(B - Y) + 0{\cdot}74\,(R - Y)$
$Q = \ \ 0{\cdot}41\,(B - Y) + 0{\cdot}48\,(R - Y)$

difference signals are much reduced, and this acuity matching greatly eases the channel-packing problem. Thus the wide-band chrominance component I and the narrow-band component Q occupy respectively one-half and one-eighth of the luminance bandwidth.

The two signals are transmitted by amplitude-modulating two quadrature components of a sub-carrier frequency, whose value is chosen near the h.f. end of the video channel and is therefore visible only as a fine-dot structure on monochrome receivers tuned to a colour transmission. Dot visibility is reduced by making the sub-carrier frequency an odd multiple of the half-line-frequency and, also, because for white (and grey-scale) subjects—which statistically form an appreciable fraction of the total scenes transmitted—the colour-difference signals are zero. (For grey-scale signals $R = G = B = Y$; therefore $R - Y = B - Y = 0$.)

In the colour receiver the received Y, $(R - Y)$ and $(B - Y)$ signals are detected and are then converted by matrices into the R, G and B signals required for the colour-display device. Thus the blue signal is derived by adding Y to $B - Y$, the red signal by adding Y to $R - Y$, and green by adding Y to a mixture of $R - Y$ and $B - Y$. Thus $G = Y - [0{\cdot}51 \quad (R - Y) + 0{\cdot}19 \quad (B - Y)]$.

Colour television in the United States

Apart from projection-tube methods, three types of cathode-ray tube for colour display received publicity during the early days of colour in the United States, namely the shadow-mask, the grid-switching and the beam-indexing tube. The only one that has been successfully marketed to date is the 21 in. shadow-mask tube, and receivers using them are on sale in the United States at from $495 upwards.

Out of a total of 50 million domestic television receivers in the United States, less than a million are colour sets, and only three or four manufacturers are making them at the moment. There is a gradual improvement in the brightness, stability and ease of setting up of colour receivers, and this is slowly breaking down 'sales resistance'.

Studio cameras are little different from those used at the start of the colour service, but modifications to image-orthicon pick-up tubes to better their sensitivity, geometry and linearity are helping to improve the quality of transmission. The relatively small number of programmes in colour each week acts as a deterrent to the sale of domestic receivers.

Colour television in Japan

At the end of 1960, Japan adopted the N.T.S.C. system in its entirety for normal broadcasting, and rapid progress is being reported. At least four manufacturers are making colour-camera equipment, and two types of shadow-mask tube (17 and 21 in.) are being marketed. The author believes that by the time of the next Olympic Games in Tokyo in 1964 great advances in colour television will have been made by the Japanese, especially in the camera field.

Colour television in France

In France, progress has been reported recently on the experimental SECAM system, which was demonstrated at Savoy Place on the 27th April 1960, when pictures were relayed directly from Paris by the Eurovision network.*

This system, although employing the general N.T.S.C. properties of the luminance signal, the two colour-difference signals, acuity matching and the interleaved sub-carrier frequency, differs from the N.T.S.C. system in that the two colour-difference signals are transmitted as amplitude modulations of the sub-carrier frequency during alternate lines. In order that the signals should be available simultaneously in the receiver for applying to the colour tube, they are stored for the duration of one line in a time-delay device.

The storage principle is shown in Fig. 1, in which the delay device is represented by a coaxial delay cable (such was the case in the early experiments). The chrominance signals are separated from the composite colour signals by the band-pass filter and are passed by the electronic switch alternately to the two colour-difference-signal detectors. Since the switch is changed over at the end of each line and since the delay in the network is one line period, a continuous succession of colour-difference signals is applied to the detectors.

The repetition of the same colouring information for two lines means that acuity matching is practised in the vertical direction as well as horizontally. The luminance signal and the two colour-difference signals are matrixed in the normal manner to form the R, G and B signals required for the display device.

In practice, the delay of 64 μs required for 625 line operation is obtained by propagating longitudinal waves through fused silica by barium titanate transducers. Pictures on this system are very similar to those received by the N.T.S.C. system. The main advantage claimed for the SECAM system is that a sub-carrier synchronous oscillator is not required in the receiver, and, therefore, phase accuracy is not as important as in the N.T.S.C. system. There seems no doubt but that for video-tape recording of colour signals this is a big advantage.

Additional tests are being carried out on the SECAM system with f.m. in place of a.m. chrominance signals, and these offer improved signal/noise characteristics and independence of colour with large variations in chrominance amplitude.

Colour television in other countries

Considerable colour-television research is taking place in Holland, Germany and the Soviet Union. An alternative method of transmitting the chrominance signals to those of both the N.T.S.C. and SECAM systems has been tested in Germany.

* August 1960 *Journal*, pp. 490, 514

In this F.A.M. scheme, the $(R - Y)$ signal is transmitted as amplitude modulation of the sub-carrier frequency, which in addition is frequency-modulated by the $(B - Y)$ signal. This avoids the necessity in the receiver for the synchronous oscillator of the N.T.S.C. system and the delay device of the SECAM system.

The United Kingdom

In the United Kingdom, colour television is bedevilled by the 405 or 625 line, v.h.f. or u.h.f. controversy and the fact that the industry is divided over the recommendations made in the report of the Television Advisory Committee, 1960. The Pilkington Committee has been formed by the Government to resolve the problems of radio and television broadcasting, and, until it reports, no decision will be made concerning the future of colour-television broadcasting.

Much research has been carried out in the United Kingdom by manufacturers and broadcasting authorities. On the receiver side, one manufacturer built a small number of 'commercial' prototype sets for early experimental 405line tests, and, more recently, other receiver manufacturers have been active in this field. Cathode-ray-tube designers are reported to be busy in their laboratories, and it is interesting to note that papers on colour-display systems were read in May 1961 at Savoy Place.

Efforts still continue with a view to improving the quality of broadcast colour-television systems. A suggestion has been made for reducing the dot visibility by making the colour sub-carrier frequency an odd multiple of one-third-line-frequency, and to make the most of this a change from 625 to 627 lines has been proposed, since by this means the 'dot crawling' pattern is reduced.

'Dot crawling' is the upward drift of the dot pattern caused by dot interlace, as can be seen if one considers the movement of, say, a positive half-wave of the sub-carrier during four successive fields.

Constant luminance

During the formulation of the N.T.S.C. system it was hoped that full use would be made of the principle of 'constant luminance', by which is meant that noise in the chrominance channel does not contribute to the brightness of the picture. However, because of the non-linear (approximately square-law) characteristics of display tubes, it was necessary to depart from the principle for colours differing considerably from white (or grey). Attempts are being made to overcome this deficiency, and thereby to improve the definition and signal/noise ratio of saturated colours. This will give monochrome viewers also better pictures.

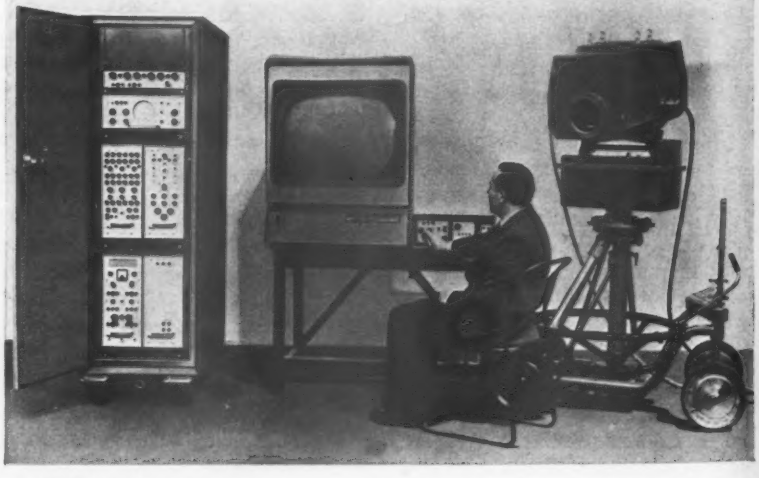
Two-colour reproduction

A sizeable furore arose about two years ago when exaggerated claims were made for the range of colours that could be seen when projecting red and white light through neutral-separation positive slides taken respectively with red and green filters. We have already seen that the requirement of sending three pieces of information for a three-colour reproduction complicates the colour receiver, for example either by phase-synchronous detection in the N.T.S.C. receiver or by the use of a line-duration delay in the SECAM receiver. Was this the answer to the cheap colour-receiver problem?

Much investigation ensued, but although a greater insight into the mechanism of colour perception was obtained the conclusion was reached that a three-colour system was still as necessary as ever for adequate colour fidelity.

Industrial colour television

While the broadcasting of colour television in Great Britain is stagnant, the same does not apply to closed-circuit television. For some years, colour television has been used at medical conferences for demonstrating operative surgery, for training in diagnosis and the like. At first, equipment similar to that employed in the United States for broadcasting was adapted, but more recently a smaller colour camera has appeared on the market, and since it uses three vidicons it is much easier



2 *Vidicon colour camera*

The weatherproof vidicon colour camera is remotely controlled from the small control panel on the right of the 21in. shadow-mask monitor. The cubicle (left) contains the channel equipment

to operate than equipment using image-orthicon tubes. It is well known that the vidicon tube has largely contributed to the rapid expansion of monochrome industrial television because of its small size, good picture quality, good signal/noise ratio and simplicity of control.

Special attention has been given in the design of the equipment to maintain maximum reliability and stability of colour balance and registration, in order that the equipment can be operated for long hours by unskilled staff. Much interest has been aroused in China, Japan and the United States in this camera, because of its adaptability. In addition to medical applications, it has been used in conjunction with microscopes to display, in colour, minute objects enlarged to a considerable size, for remote control of machinery, for telecine operation, for relaying pictures at horse-race meetings, for merchandising, for fashion parades, etc.

The most recent form of camera, shown in Fig. 2, has been designed for complete remote control of optical focusing, iris aperture, panning, tilting and turret changing, in addition to the remote adjustment of registration and gain.

Although the simultaneous system has been of major interest in recent years for industrial applications, the field-sequential system with a rotating colour disc in front of a single pick-up tube has returned to life again lately in connection with the Swiss-developed large-screen projector, which has now emerged from the laboratory with a 2kW xenon lamp. (In this display, a beam of electrons scans a film of oil, and the deformation produced modulates the light from a powerful light source by reflection from the film onto the screen.)

Summary

Summing up, we can say that there is universally a gradual improvement in the ease of operation, reliability and stability of colour-television equipment, at both the transmitting and receiving ends. The cheap colour receiver, however, is still on the horizon, and here is the largest field for fruitful research.

621.376.239 : 621.382.2

The use of mesa diodes in small-signal modulators

This note describes the use of mesa diodes in 'choppers' to overcome the production of spikes.

The author is in the Guided Weapons Department, Royal Aircraft Establishment, Farnborough.

G. G. HAIGH, B.SC.

Low-level modulators are used for the conversion of zero- or low-frequency signals to signals of higher frequency in order to make them more amenable to amplification. The literature on them is extensive, which indicates that a completely satisfactory modulator has never been produced. This present addition to the literature does no more than to describe the elimination of one big failing of modulators, namely the production of spikes.

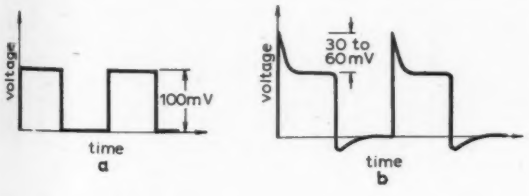
For clarity, 'chopper', which has become the common terminology, will be used in place of modulator.

Mechanical and semiconductor choppers

Several designs of mechanical chopper exist and work admirably, but, having moving parts, their frequency of chopping is low, generally less than 400c/s, and this restricts the input signal to a frequency in the range 0–10c/s. For many purposes this is adequate and, in particular, for drift-corrected d.c. amplifiers no more is required. The conversion efficiency, i.e. the ratio of alternating-voltage output to signal-voltage input, is acceptable; noise and drift can be very low indeed; and the impedance presented to the signal is very high.

Choppers using transistors, or germanium or silicon diodes, tend to be used now in place of mechanical choppers because the chopping frequency can be much higher and so allow an increased range of input-frequency variation, say 0–50c/s. Neglecting, for the moment, the temperature defects inherent in semiconductor devices, the semiconductor chopper should approach the ideal because the conversion efficiency is good and its impedance, though not so high as that of the mechanical chopper, is sufficient for most purposes, while its frequency of chopping can be several kilocycles per second.

Higher frequency of operation is, however, precluded by the generation at each moment of switching of a large spike of energy, which may completely mask the small energy content of the signal. Fig. 1 shows the desired and actual results of chopping. The spike varies with the type of circuit but is always large. Its energy content varies with temperature and age. It appears whether transistors of high or low cut-off frequency are used, and with silicon, germanium, point-contact or junction devices impartially. The spike, occurring twice for each cycle, dictates that the frequency of chopping



1 *Results of chopping*

a desired result b actual result

be kept low and nullifies much of the virtue of a semiconductor chopper.

Mesa-diode chopper

The very low forward and reverse recovery times given by a silicon diode with mesa construction suggested that its use in a chopper would be unaccompanied by spikes, and Fig. 2 shows that this is so. The forward and reverse recovery times of this mesa diode, 4ns, are lost in the relatively low rise and fall times, 1μs, of the switching circuit, and the spikes that

a

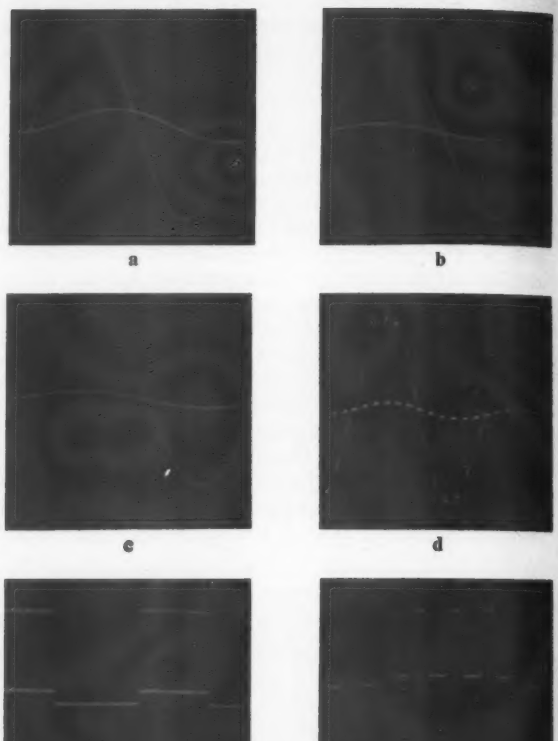
b

2 *Modulation of a steady voltage by a mesa-diode chopper*
Modulation frequency is 100000 pulses/sec
a zero input voltage
b 10mV (p–p) input
Time-base frequency is slightly different for a and b

are visible in Fig. 2 are due to direct pick-up from the switching circuit, which, when these photographs were taken, was unscreened.

Fig. 3 shows signals being modulated by the chopper. The signal and modulation frequencies were unsynchronized, and the waveforms are much better than Fig. 3 suggests. Fig. 4 shows the result of substituting ordinary junction diodes, similar in construction except for the mesa, in the same circuit. Fig. 5 shows the circuit used to obtain the results shown in Figs. 2, 3 and 4.

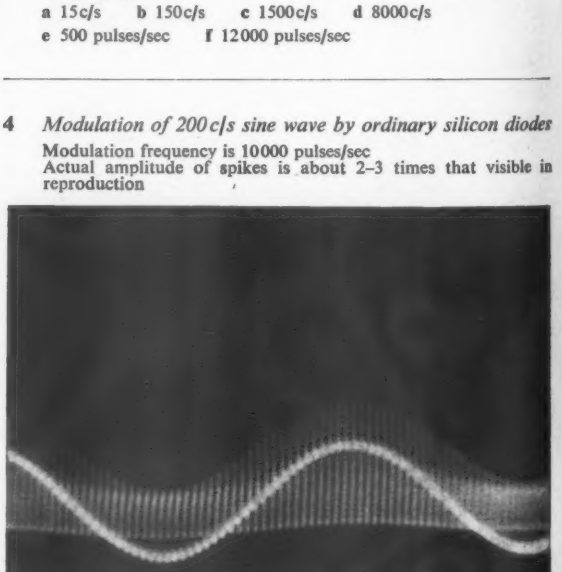
The drift with temperature of this chopper is no better than is usual with ordinary silicon diodes, say 50μV per

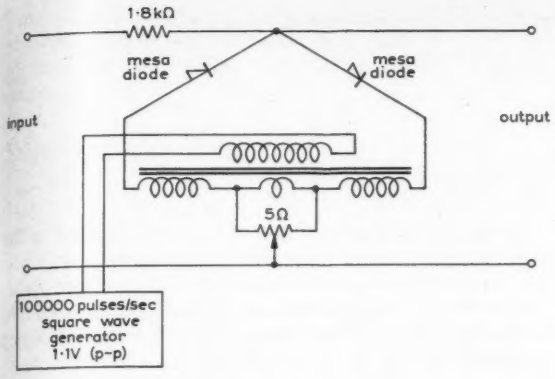


a b c d e f

3 *Modulation of signals by a mesa-diode chopper*
Modulation frequency is 100000 pulses/sec. Signal amplitude is 10mV (p–p)
a 15c/s b 150c/s c 1500c/s d 8000c/s
e 500 pulses/sec f 12000 pulses/sec

4 *Modulation of 200c/s sine wave by ordinary silicon diodes*
Modulation frequency is 10000 pulses/sec
Actual amplitude of spikes is about 2–3 times that visible in reproduction





5 *Circuit of mesa-diode chopper*

degC or less, but this drift is due to differential heating of the two diodes and can be reduced by mounting the diodes on an efficient temperature equalizer, not forgetting the relatively high thermal conductivity of the wire leads.

Symmetrical-mesa-transistor chopper

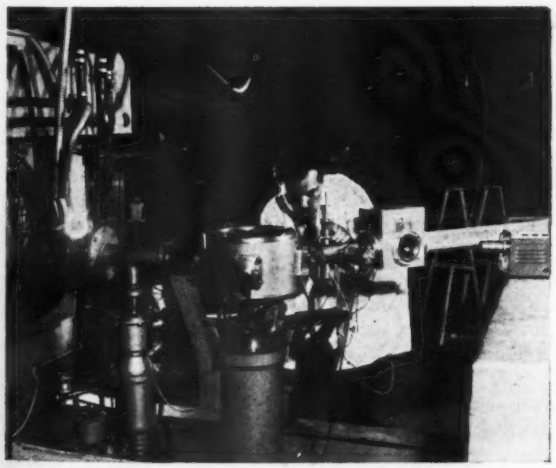
The use of a symmetrical transistor in a chopper can result in low drift with temperature changes, and it has been suggested that a symmetrical mesa transistor should show low drift without the production of spikes. This has not yet been tested by experiment, but the author's opinion is that it is perhaps easier to select two diodes for symmetry than to make a really symmetrical transistor and that close proximity of the diodes would result in a very small temperature drift. At the moment, two mesa diodes are very much cheaper than one mesa transistor.

Visit to Harwell

THE first Press visit for five years to the Atomic Energy Research Establishment, Harwell, was held recently. The functions and responsibilities of the A.E.R.E. are to carry out fundamental, basic and certain applied research in the general field of the peaceful applications of nuclear energy.

The work of the A.E.R.E. was illustrated by exhibits. The fields of work covered were basic and applied nuclear physics; basic studies of the solid state; chemistry and metallurgy of nuclear fuels; reactor chemistry and the chemistry and metallurgy of nuclear materials; studies on the chemical processing of nuclear materials; engineering research, development and operations in support of scientific work; and research and development in electronic instruments and measuring devices.

The tandem electrostatic generator (a 'doubled' Van de Graaff machine) was one of the exhibits. The illustration shows part of a broad-range spectrograph. An incident beam from the tandem generator strikes the target, and scattered particles from the target are analysed in the spectrograph.



Scattering chamber and broad-range spectrograph

The slits are adjusted so that the incident beam from the tandem generator strikes the centre of the target, which is in the cylindrical scattering chamber (centre of illustration). The spectrograph can be partly seen on the left-hand side of the illustration

New television stations

THE Independent Television Authority have two transmitters under construction in North-East Scotland. One station is at Durris, near Aberdeen. This station will broadcast on channel 9, and the signal will be horizontally polarized. The directional aerial will radiate 400kW to the north and south-west, and 15kW to the east and west.

The other station is at Mounteagle, near Inverness, and will radiate a horizontally polarized signal on channel 12. The directional aerial will radiate 50kW to the north-east and south-east, 35kW to the east, and 10kW to the west.

Trade-test transmissions will commence from the station at Durris early in September 1961 and from the one at Mounteagle two or three weeks later. The number of people covered by the two stations is about 872000.

Unattended satellite

A further 513000 people will be covered by two more I.T.A. transmitters at Caldbeck and Selkirk. Programme transmissions will commence on the 1st September 1961 from the station at Caldbeck, where horizontally polarized signals will be radiated on channel 11. The station at Selkirk will be I.T.A.'s first fully automatic unattended satellite. It will rebroadcast signals radiated from the station at Caldbeck. Initially, this station will not run unattended, because of shortage of plant. The signal will be on channel 13 and will be vertically polarized.

Ankara–, Tehran–London links

TELECOMMUNICATION links were inaugurated between London and Ankara, and Tehran and London recently. Nearly £250000 worth of equipment, provided by the United Kingdom under Central Treaty Organization arrangements, was officially handed over to the Governments of Turkey and Iran. The apparatus consisted of radiotelephone and radiotelegraph transmitters, receivers, aerials, and channelling and terminal equipment.

The assembling of moths: does radiation play a part?

621.396.677.595.78

The antenna of the male moth has been thought to be primarily an olfactory organ, used to detect the scent of the virgin female during mating periods. This article challenges that concept and presents an argument favouring a dual mechanism of moth attraction, radiation as well as scent being involved. The author is in the Electrical Engineering Department, University of Manchester.

E. R. LAITHWAITE, M.SC., PH.D.,
ASSOCIATE MEMBER

MR. F. W. Meredith, in his article 'Invention and nature' (September 1957 *Journal*, p. 490), provided many excellent examples of overlap between zoology and engineering, making the point that often an invention and its counterpart in nature are discovered about the same time, although quite independently. He also established that, in certain instances, nature's structure is obvious and man makes a simple copy. It is in the more complex mechanisms, such as the acoustic radar of bats, that man experiences the greatest difficulty in using natural phenomena as an aid to invention.

In this particular example, the accepted explanation for the bat's ability to 'fly blind' was, until 1921, based on the postulation of a sensitive organ of touch on the wing tips, capable of detecting a change in the viscous drag of the air when the bat approached an object. This tactile theory was vigorously attacked in 1794 by Spallanzani, who provided ample evidence that the theory could no longer be supported. He varnished the bats and blinded them, and showed that they flew just as skilfully as ever. Before he died he became convinced that the mechanism was auditory.

Nevertheless, in 1800, Georges Cuvier, a distinguished geologist, who was also a recognized zoological authority, wrote a sarcastic criticism of Spallanzani's work and reinstated the tactile theory. It is reported that Cuvier was 'lauded by all biologists for having brought order out of the chaotic state'. A century of comment followed, mostly anti-Spallanzani, perhaps the most forthright of which was 'Since they see with their ears, what do they hear with their eyes?' The great stumbling-block in this case was the inability of the observers to hear or detect the bat's high-frequency note. It was left to Hartridge, who had worked on supersonics in World War I, to confirm the acoustic theory. R. Galambos's delightful account* of Spallanzani's contribution is an object lesson for every scientist.

* GALAMBOS, R.: 'The avoidance of obstacles by flying bats; Spallanzani's ideas (1794) and later theories', *Isis*, 1942, 34, pp. 132–140

Without wishing to draw too close a parallel to the Spallanzani case, this article is concerned with an aspect of the behaviour of certain species of moth that appears to be worthy of investigation in view of the fact that evidence exists which conflicts with the generally accepted explanation.

Assembling of moths

It is well known that the females of certain species of moth are able to attract males of their own kind from considerable distances. Reliable experimental evidence is available that indicates that marked males have flown in almost a direct line to a female placed one mile away.* This phenomenon may be displayed to a greater or lesser extent by all species of moth, although attention has naturally been focused on those species in which the sense is most highly developed.

It is also common knowledge among entomologists that only virgin females are suitable for enticing males in this way and that, once a female has mated, the attraction ceases. A further piece of well known experimental fact is that an empty box which has contained a virgin female can be used to attract males of the same species. In certain species, the females are virtually wingless, making some degree of assembling almost essential for the continued reproduction of the species.

Insect communication

Similar mating phenomena to the assembling of moths occur in other orders of insect life, and in many cases the mechanism of communication is more or less understood. The nature of such mechanisms may be classified as (a) acoustic, (b) electromagnetic radiation, and (c) olfactory. Included in (a) is the high-frequency call of the female mosquito, while an example in group (b) is to be found in the 'lantern' of the glow-worm, which uses radiation in the visible part of the electromagnetic wave spectrum. The almost universally accepted explanation for assembling in moths is that the males detect a scent emitted by the female, and the mechanism therefore falls into class (c).

The 'empty-box' phenomenon is probably largely responsible for the early belief that assembling was attributable entirely to an olfactory mechanism. Other observations provide further evidence in favour of such a theory. Scent glands that are exposed in the virgin-female moth become retracted after mating. The antennas of the males of species which assemble most readily are invariably highly pectinated as shown in Fig. 1b, a

* IMMS, A. D.: 'Insect natural history' (Collins, 1947), p. 89

feature that undoubtedly gives them a much larger area than that of a filiform structure (Fig. 1a). The male antenna has been established as an organ for detecting scent particles.

Evidence on assembling

Examination of the available evidence on assembling, however, shows that the case for an olfactory mechanism is far from proved. To detect a scent is to absorb molecules of a substance. A scent field is essentially a scalar field, and an observer may only attempt to find the direction of the source by moving relative to the scent particles and taking a time-derivative of intensity. This is clearly possible if the source is situated in calm air, so that the scent diffuses out in a regular manner, but a glance at any aerial photograph which depicts smoke drifting across a landscape shows clearly that the contour map of smoke-particle density is very complicated. In such circumstances the observer is unlikely to detect the source by moving in virtually direct lines—yet such is the flight of the male moth seeking his mate.

The second piece of evidence that is difficult to explain is that of the empty box. If a virgin female is placed on the ground for a few hours, she will emit scent particles to the surrounding area of such intensity that males will continue to be attracted to that spot for several days after she has been removed. If, however, she is allowed to remain there and to mate, the attraction for her and the locality apparently ceases. If scent alone is responsible for the attraction, she must have a method of deodorizing the surrounding area after mating. This seems unlikely, and indeed all attempts at isolating a deodorizing fluid or producing it artificially have so far been unsuccessful.

1 *Structure of moth antennas*
a filiform
b bi-pectinate (male)
c bi-pectinate (female)

The antennas of moths are certainly scent receptors. It is argued that the pectinations, as shown in Fig. 1b, are the result of an evolutionary development whose sole object is to increase the surface area and hence the sensitivity of the instrument. To the electrical engineer, however, the highly organized arrangement and shape of the pectinations suggest that there may be a second use for these organs. It is quite common, biologically, for one organ to perform two functions.

Radiation theory of assembling

The very word 'antenna' suggests aerials for receiving electromagnetic waves. Examination of the antennas of male moths indicates that, if they were aerials of this kind, the operating wavelength could be of the order of 0·01–0·001 cm, which is just shorter than the wavelengths which can be produced electrically. This range of wavelengths is included in the far infra-red band, about which little is known.

The new radiation theory of assembling suggested here attempts to link the phenomenon of assembling with that of attraction to light, which is sufficiently well known to have become proverbial. The behaviour of a moth in the presence of a light may be explained in terms of internal servomechanisms at work, which cause the wings to vibrate more rapidly at one side than the other, depending on which side the light is situated relative to the moth, so that the insect is guided in its flight towards the light source. This, however, does not explain the mechanism of the stimulus.

Two experimental facts concerning light attraction are taken to be of prime importance in building the new theory. First, of the total number of moths which may be attracted to a light source, by far the majority are male. Secondly, attraction to light is much stronger in a damp atmosphere than in a dry one. In the new theory, the mechanism of light attraction is explained by the molecular absorption of part of the incident visible light photons on water-vapour molecules, resulting in photons of longer wavelength being emitted. These are detected by the male moth and interpreted as the mating call of the female.

This molecular absorption (Raman scattering) enables an explanation to be given as to how a moth may receive an infra-red signal through a glass window known to absorb the long infra-red waves. The visible light passes through the glass and strikes the water-vapour molecules in the vicinity of the moth. Since the intensity of the resulting radiation is proportional to the intensity of the visible light at that point, a sense of direction may thus be obtained. The effect on the moth may be imagined by comparing it with the visual effect obtained from a street lamp on a very foggy night: an observer in these circumstances is aware of a general increase of 'luminous fog' before he actually sees the lamp itself.

As regards the assembling phenomenon, the theory proposes that assembling is based on two distinct mechanisms: a radiation mechanism operating at long distances and an olfactory mechanism at short range. Such dual mechanisms are common in nature: a dog, following the trail of a rabbit by smell, abandons the trail once he sees the rabbit.

Common Vapourer moth

A number of experiments were carried out on the Common Vapourer moth (*Orgyia antiqua*). This species has a wingless female, is very common and flies and mates by day, making experiments relatively easy to perform. The early experiments were carried out because of certain conflicting publications regarding the effect of wind on assembling and in order to investigate the question of decontamination raised by the empty-box experiment. Vapourer moths naturally breed in colonies, since the only time at which females are mobile is in the larva stage, at which time movement is obviously restricted to short distances.

It is therefore comparatively easy to capture males, take them some distance away, and release them with the knowledge that the only females in the neighbourhood are those in the colony. Males treated in this way were able to find the colony rapidly, whether released up- or down-wind in a 10 m.p.h. breeze. This suggests that scent alone is an insufficient explanation.

Males released within a few feet of a mated female were attracted to the female just as if a virgin female had been used. These males remained in attendance for several hours, despite the lack of co-operation on the part of the female. A similar attraction was noted for a dead female, a female pupa, eggs newly deposited, and an empty box which had recently contained a female. None of these 'baits', however, appeared capable of attracting males from a colony some hundred yards away, whereas a virgin female was rapidly surrounded by several males from the distant colony. These results suggest strongly that two mechanisms are involved.

Evidence for radiation theory

Positive evidence in favour of the radiation theory is difficult to obtain. No substance is known which will transmit the long infra-red; otherwise, it might have been possible for males to be assembled to a female in a sealed box from which scent could not escape. Some evidence was obtained, however, using the apparatus shown in section in Fig. 2. A brass tube, 15in. long and having a small hole near its base, contained a tray connected to a rod, which was capable of being lifted out of the cylinder. The tray was a reasonably close fit inside the cylinder.

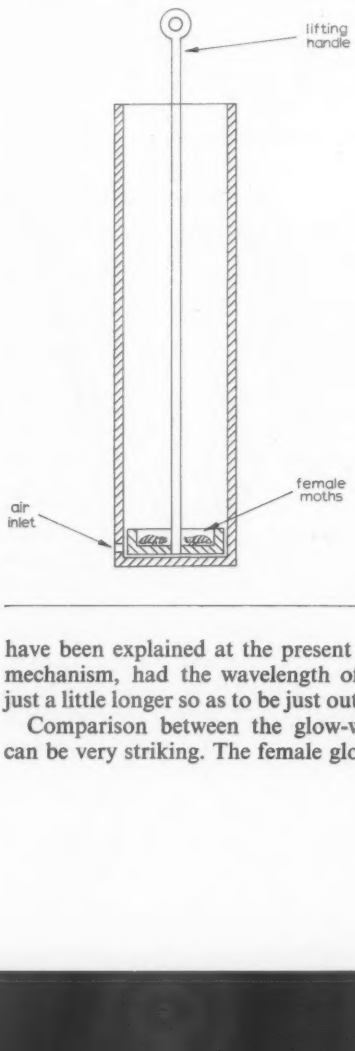
Six virgin females were placed in the tray, and the apparatus was set up about 100 yards from a colony. Every half-minute the tray was raised to the top of the cylinder by means of the rod, thereby forcing a column of contaminated air out into the atmosphere. The metal tube acted as a screen to any radiation, except for a narrow cone vertically above the tube, which males were likely only to encounter accidentally. During a 3h period, three males located the tube. On the next day, in similar weather conditions during the same 3h period, the same six females placed in the open attracted 64 males, each of which was captured before it could mate.

On the third day, no females at all were used, but observation was kept on the number of males that happened to pass within 20ft of the locality within the specified period—the number in fact was four.

It seems likely that, if the female emits a radiation to attract the male, she does so in a series of pulses that would certainly be more easily detected than would an emission of constant intensity. The movements of the female abdomen, which are normally assumed to have the sole purpose of exposing scent glands, occur about 60 times per minute in the case of the Vapourer. A possible line of research might be to use a sensitive bolometer, capable of detecting small quantities of infra-red radiation, to detect radiation from the female. The construction of apparatus of the required sensitivity with a response fast enough to observe pulsations is difficult. The problem of producing a conclusive experiment is similar to Spallanzani's problem.

Observations

A radiation mechanism of assembling could be very similar to the mating mechanism of the glow-worm. The only difference would be that, whereas the moth radiation is invisible, the radiation from the female glow-worm is visible, a fact that makes it very easy for us to observe the mating signal. It is an interesting speculation as to whether the assembling of male glow-worms would also have been explained at the present time as an olfactory mechanism, had the wavelength of the radiation been just a little longer so as to be just outside the visible band.



2 *Screening apparatus used in experiments on the Vapourer moth*

Comparison between the glow-worm and the moth can be very striking. The female glow-worms cannot fly,

so that long-range signalling becomes essential; such is the case with moths like the Vapourer, in which the female is wingless. The female glow-worm can control the light emission and turn it off after pairing; so apparently can a female moth, and it seems unlikely that cessation of exposure of scent glands would prevent further attraction, from the evidence of the empty-box experiment.

The new theory can account for such facts as the failure of moonlight to attract moths. This could be the result of a lack of intensity gradient. The fact that some females are attracted to light may be explainable in terms of the rudimentary male organs in the female (Fig. 1c) and the fact that the attraction to light is a far stronger stimulus than that of a male.

One further observed fact, for which so far no satisfactory explanation can be offered, is that the male Vapourer appears to be attracted during daylight by glass window-panes, and males may often be seen apparently trying to get into a house through a window, in much the same way as a butterfly would try to get out if released inside a room, even though the interior of the room is dark compared with the illumination outdoors.

Clearly, there is scope for further work on this subject, with the possible reward of some information about electromagnetic waves of teracycle frequency.

Acknowledgments

The author is indebted to Dr. E. J. Popham of the Zoology Department, Manchester University, for encouragement and much useful discussion leading to the preparation of this article.

Summary

The article has presented a case favouring the proposition that radiation plays a part in the assembling of moths.

The author will be glad to learn of any further experimental evidence: in particular, any observations that may have been made in countries where the moth population includes such large species that the relevant wavelength could well be 0·05cm or longer. Evidence of a reaction from these insects in the vicinity of a microwave transmitter could well be the starting-point of a most interesting series of experiments.

Conference on microwave measurement techniques

THE Electronics and Communications Section is arranging a conference on microwave measurement techniques, which will be held at Savoy Place from Wednesday, 6th, to Friday, 8th September 1961.

Rapid advancements

The rapid progress made since the 1939–45 War in microwave applications has, as one would expect, been accompanied by a corresponding development of new and more precise measurement techniques.

Microwave measurements are necessarily very different from their more familiar counterparts at lower frequencies, and they form a fascinating study as well as a rewarding experience. The techniques move forward so rapidly that even for the specialist it is difficult to keep in touch with their many different aspects.

The conference aims not only to bring together for mutual discussion topics representing the most recent additions to our knowledge of this subject, but also to present a unified picture of the most fruitful approaches to the various problems, thus enabling those working in allied fields to get full benefit from the discussions. With that object in view, each session will start with an introductory lecture surveying and pinpointing problems of special interest to be discussed in detail during the presentation of the more specialized contributions.

The conference thus gives a unique opportunity to look afresh at some of the problems of microwave measurement and, by exchange of information, to help forward the development of techniques in this most important and interesting part of the spectrum. It is expected that a wide cross-section of those concerned with electrical measurement will register for the conference.

Conference programme

The programme for the conference is given below:

WEDNESDAY, 6TH SEPTEMBER

10 a.m. Session 1—**Introductory session, including special topics in microwave measurements**
Introductory lecture by Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.), F.R.S.

2.30 p.m. Session 2—**Impedance, admittance and reflection coefficients**
Introductory lecture by Prof. H. M. Altschuler

THURSDAY, 7TH SEPTEMBER

10 a.m. Session 3—**Power measurement**
Introductory lecture by Prof. A. L. Cullen, O.B.E., PH.D., B.SC.(ENG.)

2.30 p.m. Session 4—**Waveguide propagation characteristics and attenuation measurements**
Introductory lecture by L. Lewin

FRIDAY, 8TH SEPTEMBER

10 a.m. Session 5—**Millimetre-wave measurements**
Introductory lecture by Dr. W. Culshaw

2.30 p.m. Session 6—**Measurement on materials**
Introductory lecture by I. A. Harris

Courier communication satellite

621.396.946

The Courier-communication-satellite experiment was undertaken to demonstrate the feasibility and operational capabilities of a delayed-repeater satellite transmission system and to provide a basis for estimating the usefulness and capacity of long-range multi-station store and forward message-handling capability utilizing a satellite vehicle. This article discusses the exchange of messages between ground stations through the Courier satellite, gives a typical operating sequence and describes the satellite.

The authors are employed at Fort Monmouth, N.J., U.S.A. Mr. Siglin is Chief, Astro Communications Branch, U.S. Army Signal Research and Development Laboratory. Mr. Senn is Chief Engineer and Civilian Director, Systems Engineering Office, U.S. Army ADVENT Management Agency.

PIERCE W. SIGLIN and **GEORGE SENN**

On the 4th October 1960 at 1750 G.M.T., the Courier 1B communication satellite was launched in the United States from Cape Canaveral, Florida. The satellite contained one of the most sophisticated pay-loads ever to be sent into space by the United States. The pay-load was protected from atmospheric friction by the bulbous nose shroud of the Thor–Able–Star missile (Fig. 1). The shroud was jettisoned after the missile passed through the Earth's atmosphere. Forty minutes after being launched, the Courier satellite was injected into an orbit inclined 28·3° to the Equator.

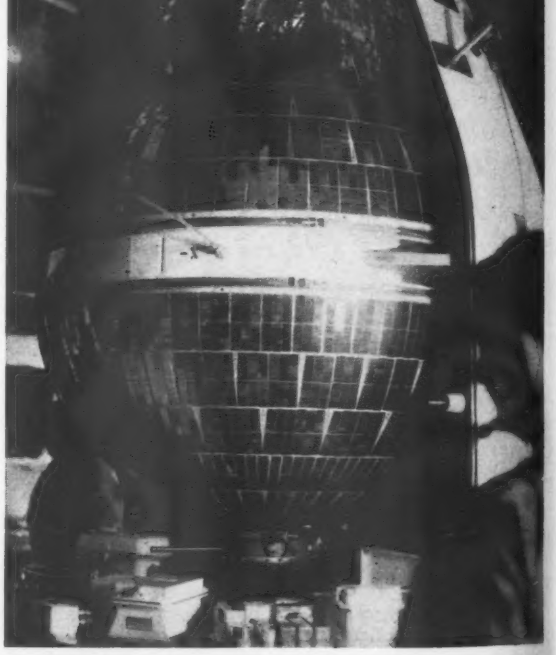
Approximately 75 min later, ground-station installations at Fort Monmouth, New Jersey, and Camp Salinas, Puerto Rico, were exchanging messages through the Courier satellite. The launch was completely successful, having attained a satellite orbit with an apogee of 755 miles, a perigee of 598 miles and a period of 107 min.

Exchange of messages

The Courier system uses an Earth-orbiting satellite as a radio-relay station to exchange messages between ground stations as a 'real-time' repeater when both ground stations can 'see' the satellite at the same time, or as a 'delayed' repeater by recording the messages received from one ground station and transmitting these messages to another ground station at some later time on the satellite receiving the appropriate command. For the purpose of implementing both types of experimentation, the ground stations were located at Fort Monmouth and Camp Salinas.

The altitude and inclination of the satellite orbit permitted an average of five workable orbits at the Fort Monmouth station and an average of seven at the Puerto Rico station out of approximately 14 orbits per day. The time-in-view of the satellite at the ground stations varied from 8 to 19 min for these usable orbits, with much overlap in the time-in-view of the respective stations. This overlap was utilized for experiments involving the real-time relay of message traffic.

The Courier satellite carries a standard v.h.f. beacon to permit tracking by the existing world network of satellite-tracking stations in order to establish ephemeris data for use by the Courier ground stations. The ephemeris data furnished to each ground station provide a series of antenna azimuth and elevation pointing angles plotted over discrete time intervals for each passage of the satellite over a ground station.



1 *Shroud installation of Courier 1B satellite*

For ease of acquisition, the ground station transmits the initial 'turn on' command via the v.h.f. link. Once acquired, further exchanges of messages and commands between the ground station and the satellite are accomplished over the microwave link. Telemetry data

are transmitted from the satellite to the ground stations over the v.h.f. link.

The selection of very high operating frequencies for the acquisition telemetry and initial-command link was made to take full advantage of the wide antenna beam-widths at these frequencies, which made initial acquisition of the satellite fairly simple. A microwave communication link was chosen to provide the channel bandwidth compatible with the message traffic and to take advantage of the excellent propagation and noise-free characteristics of the microwave frequencies.

Operating sequence

The ground-station antenna is directed to the point in space where the satellite should be first acquired. When the signal from the satellite v.h.f. beacon is received by the Courier ground station, the station console operator issues the 'turn on' command over the v.h.f. ground-to-satellite link. This command turns on the microwave communication transmitters and receivers in the satellite, turns off the v.h.f. beacon and activates a higher-power telemetry transmitter that operates on the same very high frequency as the beacon. Following warm-up of the microwave transmitters in the satellite, the ground-station antenna automatically tracks the satellite for the remainder of the pass on the microwave communication-link frequency.

With automatic tracking assured, an exchange of stored-message information can be simultaneously carried on between the ground station and the satellite. The ground station will command a tape recorder in the satellite to play back recorded messages. These messages will be recorded on magnetic tape at the ground station. Simultaneously the ground station will command another tape recorder in the satellite to record, and messages will be transmitted to the satellite from previously recorded magnetic tapes at the ground station.

This operation can be repeated for each of the five tape recorders carried by the satellite. Four of the recorders are used to record teletypewriter messages in digital form; the fifth recorder is an analogue type used for recording voice or facsimile messages that can be handled in a 300–50000c/s bandwidth. The record or play-back time of each recorder is 4min. Teletypewriter data are transmitted to or from the digital recorders at a rate of 55000 bits/second. In the 4min of transmission time, 13200000 bits, equivalent to 300000 words, can be recorded on, or played back from, a digital recorder. The exchange of messages is limited by the time-in-view of the satellite over the ground station.

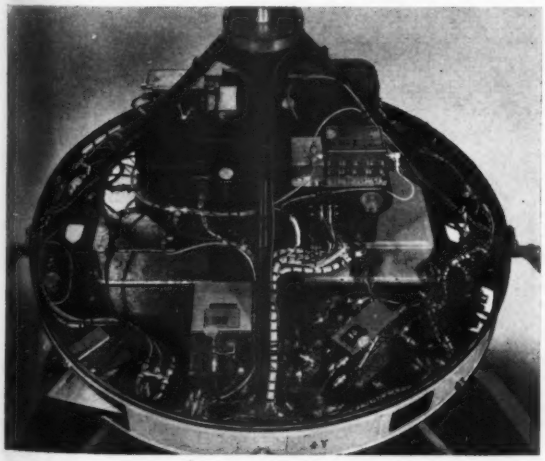
On completion of the traffic exchange, the ground station commands the satellite to assume the standby mode of operation, with only the acquisition beacon transmitting on very high frequency. If the satellite should pass out of the command range of the ground station before this final command can be issued, the satellite will automatically assume the standby condition after a 20sec delay.

This description of a typical operating sequence describes the delayed-repeater type of operation. If there is an overlap of the time-in-view for two ground stations, the satellite may be commanded to operate a real-time repeater station, in which the message traffic passes through the satellite electronic circuits immediately, without being recorded.

The Courier-system design was based on a 750mile-altitude, approximately circular orbit. The significant parameters of the system are listed in Table 1.

Table 1. System parameters

	satellite	ground station
a U.H.F. circuits		
power output	4W	1000W
noise figure	14dB	—
noise temperature	—	640°K
i.f. bandwidth	550kc/s	100, 200 or 500kc/s
antenna gain	−4dB	41dB
antenna polarization	linear	circular transmission diversity reception
carrier/noise ratio at 3000 miles slant range:		
satellite to ground	22dB	
ground to satellite	21dB	
b V.H.F. circuits		
standby power output	50mW	—
active power output	1·5W	100W
noise figure	8dB	4db
i.f. bandwidth	30kc/s	6kc/s
antenna gain	−4dB	19dB
antenna polarization	circular	linear transmission diversity reception
carrier/noise ratio at 3000 miles slant range:		
satellite-to-ground standby	18dB	
satellite-to-ground active	25dB	
ground-to-satellite	32dB	



2 *Interior view of Courier 1B satellite*

Description of satellite

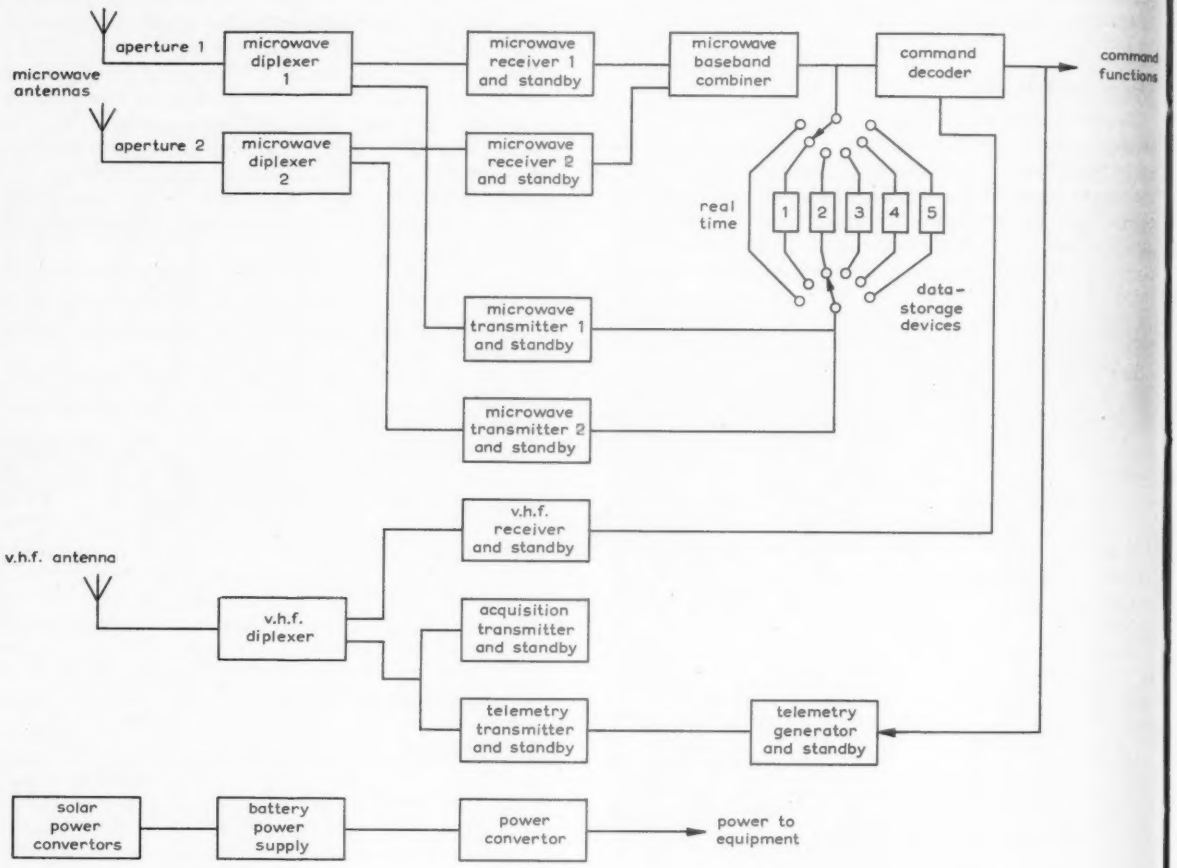
The Courier satellite is a glass-fibre and epoxy-resin sphere, 52in. in diameter, and weighs 500lb. The surface

of the sphere is covered with 19152 solar cells protected by optical-glass filters. The electronic components are mounted on central, upper and lower honeycomb glass-fibre and epoxy-resin platforms supported on aluminum-tubing trusses (Fig. 2). Four v.h.f. whip antennas are mounted at equidistant points around a central band of magnesium, and two notched-fin microwave antennas are located at opposite points on the magnesium band.

and microwave receivers, and the nickel/cadmium batteries.

The satellite standby-power requirement is 13W; the peak power demand during an exchange of recorded messages is 225W. The solar power supply is capable of providing 60W of peak power to charge the batteries during standby portions of the orbit.

Thirty-five satellite parameters are telemetered to the

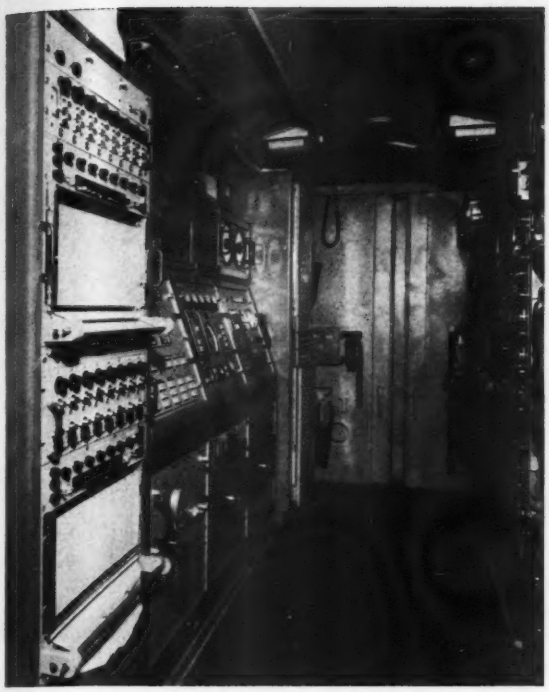


3 *Block diagram of satellite*

Fig. 3 is a block diagram of the electronic circuits of the satellite. Approximately 1300 transistors and solid-state diodes are used in the satellite. The four microwave transmitters use planer triode vacuum tubes. Much emphasis has been placed on the use of redundant circuits to improve the reliability of operation.

Two microwave transmitters are used to provide the frequency-diversity transmission from the satellite. The remaining pair serve as redundant units to be switched into the circuit on command from the ground station. Redundant units are furnished also for the acquisition beacon, telemetry transmitter, code tape readers, v.h.f. ground station over the v.h.f. satellite-to-ground link. The telemetered positions are seven temperature points, two battery voltages, two battery-charging currents, tape position on five recorders, power output of microwave and telemetry transmitters, and the a.g.c. voltages of both v.h.f. and microwave receivers.

The five tape recorders carried by the satellite weigh 5lb each and consume 10W. The recorders are designed to record and play back in opposite directions. Consequently, message traffic is read out of the recorders backwards, and this makes necessary a compensating reversal of traffic elsewhere in the system. On play-back,



4 *Operating console and message-processing centre*

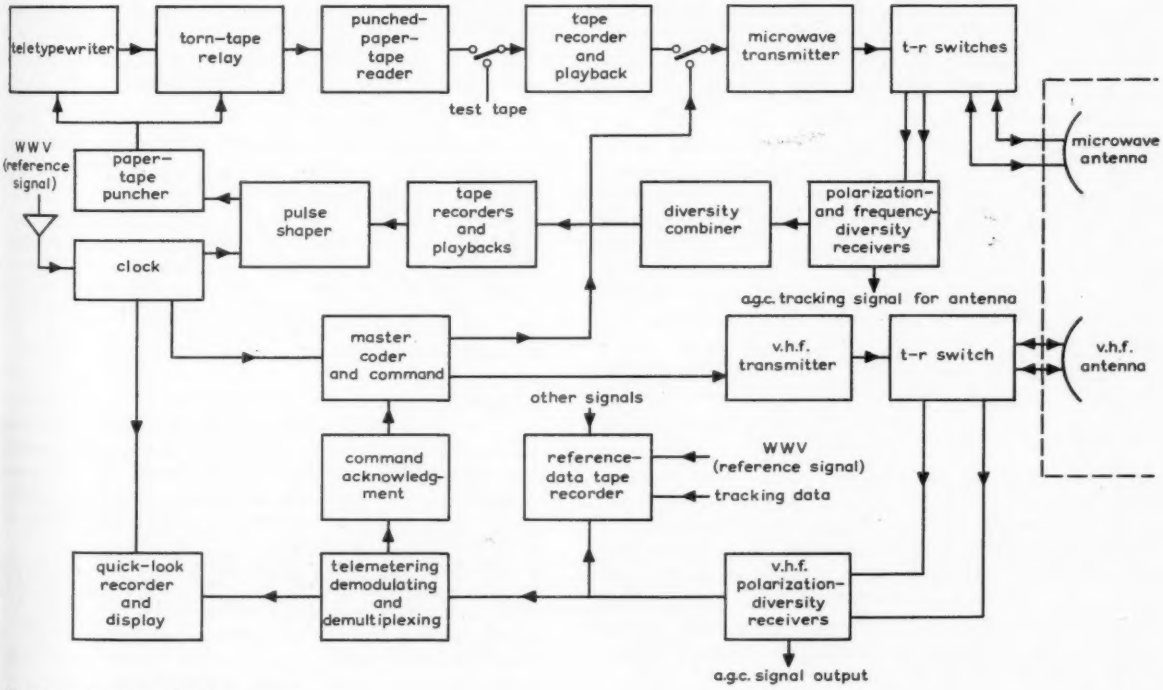
the traffic is automatically erased by a permanent magnet. All recorders are hermetically sealed in welded aluminum cases. This sealing procedure ensures operation of the recorder moving parts in the space environment.

Ground stations

A Courier ground station comprises a 28 ft parabolic antenna, three trailers and a maintenance van. The trailers serve to house the communication co-ordination control equipment, an operating console and message-processing centre (Fig. 4), and the ground-station microwave and v.h.f. receiving and transmitting equipment. A block diagram for the ground station is shown in Fig. 5. The antenna feed includes feed elements for both microwave and v.h.f. frequencies and a motor-driven lens scanner to provide conical scan at microwave frequencies for the automatic-tracking antenna system.

The v.h.f. receivers are of double-superheterodyne design. Signals from the satellite acquisition beacon and telemetry transmitter are received over this v.h.f. equipment. The telemetry data from the satellite are recorded in strip-chart form and on magnetic tape. The strip-chart record is useful in establishing the tape-recorder loading situation and the charge condition of the satellite batteries at the beginning of an operating sequence.

A frequency-diversity system of transmission is used in the satellite to minimize the transmission effects of the satellite spinning and tumbling as it speeds along in outer space. The ground-station receiving system utilizes four parametric convertors used in a double-conversion



5 *Ground-station block diagram*

superheterodyne system to provide both frequency and polarization diversity reception at the ground station.

Traffic capacity

The high teletypewriter-message traffic capacity for the Courier system is achieved by the use of several speed-changing techniques. Teletypewriter messages on paper tape are converted into electrical signals and recorded on magnetic tape at a speed of 1·68 in./s (200 characters/sec). The magnetic tape is played back at a speed of 60 in./s (7140 characters/sec). The electrical signals from the magnetic tape are converted from parallel to serial form and are used to frequency-modulate the microwave transmitter at a rate of 55 000 bits/sec.

Messages from the satellite are converted from serial to parallel form and recorded on magnetic tape at a speed of 60 in./s. The tape is played back at a speed of 1·68 in./s, and the electrical signals operate a paper-tape perforator to produce a paper tape for use by standard teletypewriter machines.

6 Facsimile picture transmitted in real time

Voice- or analogue-message traffic is processed in a special manner. The message is recorded on magnetic tape at unity speed. The tape is then reversed and played back at twice unity speed, with the signals being transmitted to the satellite. Analogue traffic received from the satellite is recorded at twice unity speed. Play-back of this tape at unity speed provides the original voice message.

Performance

The Courier satellite performed in an exceptionally satisfactory manner from launching on the 4th October until the 21st October 1960. Since the 22nd October the satellite has not responded to any commands transmitted from the ground stations. The acquisition transmitter continues transmitting, indicating that the satellite is in the standby mode of operation. Throughout the operating period, approximately 6 million words were transmitted daily between the ground stations. Real-time voice transmission as well as facsimile were successfully demonstrated during this period (Fig. 6).

Summary

In spite of the relatively short life of the command capability of the Courier satellite, it demonstrated, unequivocally, the capabilities of such a system. An impressive amount of communication was handled between the two ground stations; this amount was an economic proportion of the normal transoceanic administrative traffic carried by conventional systems during a similar period. The accuracy and dependability of the transmission system established by the Courier communication satellite were equal to those with h.f. radio and competitive with those of cable systems. The technical capability of a satellite system has been completely demonstrated by this experiment. Its utilization as a means of transmitting intercontinental, near-real-time traffic can now be evaluated on economic and requirement grounds.

COLLEGES OF ADVANCED TECHNOLOGY

RECENTLY, the Minister of Education, Sir David Eccles, discussed the status of the colleges of advanced technology. He recalled that in 1956 about half of the work of these colleges taken together was not advanced work at all. Yet, within a few years, the local authorities concerned with the colleges had made arrangements to disperse the lower-level work to other colleges.

However, problems were arising which demanded more effective co-ordination between the colleges of advanced technology themselves and between these colleges and the universities. Staff, especially in the higher posts, was the most urgent need. This was partly a question of status, particularly in the sense of the staff playing a more decisive part in the government of the college.

The question whether these colleges should be allowed to give degrees or, at any rate, their own academic awards was essentially a matter for the Robbins Committee. The Government proposed, however, to give the colleges of advanced technology a new status under independent governing bodies who would receive direct grants from the Ministry of Education.

LETTERS TO THE EDITOR

ONE VOICE FOR ENGINEERING

Dear Sir—In his address at the Annual Dinner of The Institution on the 23rd February 1961 (April 1961 *Journal*, p. 220), the President called attention to the discussions now taking place between the institutions on the formation of an organization that could speak for engineering as a whole with one voice. I believe that such an organization would be of immense benefit to the engineering profession and consequently to the community we serve.

Sir Hamish referred also to the status of the engineering profession, and in this connection the statement published in the May 1961 *Journal*, p. 270, about the Engineers' Guild is very relevant.

Although with limited support, the Guild already speaks for the engineering profession as a whole in matters outside the fields of learned technology and has gained considerable experience in these matters, counting some very distinguished engineers among its members. Is it too much to hope that the Guild will be brought into the discussions taking place, especially as its objects—'to promote and maintain the unity, public usefulness, honour and interests of the engineering profession'—are so closely allied to the aims that would be those of any new institution or joint council such as the President suggested?—Yours faithfully,

D. N. DE MATTOS
Little Orchard
Murch Road
31st May 1961 Dinas Powis, Glamorgan

WATTS AND VARS

Dear Sir—Of course volt-amperes, watts and vars are quantities of the same dimensions and nature (June 1961 *Journal*, p. 367).

Imagine an a.c. source feeding a resistance, an inductance and a capacitance in parallel, the reactive elements being loss-free and tuned ($\omega^2CL = 1$). There will be a pulsating flow of energy from the source into the resistance, where the energy turns into heat and escapes from the system. There will also be a periodic exchange of energy between the inductance and the capacitance, this energy being conserved within the system.

Rate of flow of conserved energy between the reactive elements is just as much power as is rate of flow of the 'escaping' energy between source and resistance. It may be convenient to distinguish between energy that leaves the system and energy that is conserved therein, but this does not affect the nature of things. May I suggest the analogy of money that circulates within a country and money that goes abroad—both money, but in different accounts?

I suggest that Prof. Kapp's first conclusion is the correct one.—Yours truly,

B. L. GOODLET
Falcon Works
20th June 1961 Loughborough

One voice for engineering.....D. N. de Mattos, B.SC.(ENG.), ASSOCIATE MEMBER

Watts and vars.....Prof. B. L. Goodlet, O.B.E., M.A., MEMBER; D. A. Bell, M.A., B.SC., PH.D., MEMBER; T. Palmer, B.A., GRADUATE; A. G. Warren, MEMBER; E. G. Semler, B.SC.(ENG.), A.M.I.MECH.E.; Karl Sailer

Depreciation of engineering plant.....D. J. Bolton, M.SC.(ENG.), MEMBER

Voting procedure.....Selwyn Palmer, B.SC.(ENG.), ASSOCIATE MEMBER; Cmdr. J. C. Turnbull, R.N., MEMBER

Inversion and contour plotting...H. McKibbin, M.SC., PH.D., ASSOCIATE MEMBER

Cosmic electrical discharges—4.....C. E. R. Bruce, M.A., D.SC., MEMBER

Dear Sir—Prof. R. O. Kapp (June 1961 *Journal*, p. 367) refers to a document of the International Organization for Standardization that I have not seen, and I am wondering whether some of the difficulty arises from the difference between 'numerically equal', 'dimensionally equal' and 'identical'.

Surely no physicist asserts that quantities that have the same dimensions are identical in the sense of being physically interchangeable? The classic example is that torque is measured as the product of force and radius, and work or energy can be measured as the product of force and distance moved. Therefore, both have the dimension of force × length, but no one asserts that torque and energy are identical.

Apart from checking the form of an equation, the theory of dimensions claims to be able to indicate the kinds of physical measurement that must be made in order to determine the quantity in question. The determination of both watts and vars may be based on the measurement of voltage and current, so that they are said to have the same dimensions. The distinction between them then involves measurement of a phase angle; but 'angle' is dimensionless, and the theory of dimensions therefore cannot make the discrimination. Perhaps engineers have unwittingly brought this on themselves by tacitly working in time-averages of sinusoidal quantities.

If we worked basically in instantaneous values, and stated our averaging processes explicitly, we could agree that the only fundamental quantity is the volt-ampere. Whether we wish to adopt the convention of calling the true (instantaneous) volt-ampere a watt is another matter.—Yours faithfully,

D. A. BELL
Reader in Electromagnetism
University of Birmingham
21st June 1961 Edgbaston, Birmingham 15

Dear Sir—Prof. R. O. Kapp's letter in the June 1961 *Journal*, p. 367, was the first news I had had that a conspiracy was afoot to proclaim the equality, as units, of volt-amperes, vars and watts. I read it with a mild shock.

On second thoughts, there are certain difficulties in objecting to the change. The situation at the moment is that, when voltage and current are given, the ratio is always expressed in ohms, whereas the product is given in watts, volt-amperes or vars. Is this not rather odd?

Consistency seems to demand either:

(1) that we give up the ohm as a general unit, applicable to circuits containing resistance only, reactance only, or resistance and reactance combined. (This would entail the adoption of new units.) or

(2) that we introduce the watt (or, at any rate, *one* unit) as the general unit for the product.

The fact that resistance, reactance and impedance are all measured in ohms does not stop us drawing impedance triangles and using the relation: $Z^2 = R^2 + X^2$.

As far as I can see, there is nothing in the introduction of the watt, as the other general unit, to prevent our using a similar relation between volt-amperes, power and reactive volt-amperes, when they are all measured in watts.

It seems to me that when the physicists agree to use 'watts' in the new general sense, they have, in effect, redefined the word; it does not seem relevant, then, to object to statements in which the word has its new meaning, on the ground that the statement is absurd if we interpret 'watts' on the old basis. To avoid this misunderstanding it might be better to use a completely new word that replaces 'watts'—'kapps', for instance?

Having tried to defend the physicists, I ought to add that I was leaning over backwards in an attempt to be fair to them. From the point of view of a teacher, I think there is something to be gained from achieving consistency by introducing new units for resistance, reactance and impedance—even though they all have the dimensions of resistance: rohms and zohms spring to mind. For reactance we could use lohms or cohms.

I would also keep watts, volt-amperes and vars; though the theory of dimensions may be important, it is not the only theory. The terms remind us of important distinctions.

Knowing that some physicists are opposed to the M.K.S. system, I would be grateful if someone could tell me whether it is approved by the physicists who want to limit us to 'watts'.—Yours faithfully,

T. PALMER

27 Burlington Avenue
28th June 1961 Kew, Richmond, Surrey

Dear Sir—I agree with Prof. Kapp in his letter in the June 1961 *Journal*. Any shorthand presumes some intelligence on the part of the user, and so far watt, VA and var have been understood. Does the I.S.O. intend, gratuitously, to create a confusion?

I await the day when standardization committees will cease straining at gnats and will regurgitate camels.—Yours faithfully,

A. G. WARREN

Armament Research and Development Establishment
Fort Halstead
30th June 1961 Sevenoaks, Kent

Dear Sir—While the principle of dimensional analysis of units is a sound one, I am surprised to learn from Prof. Kapp's letter in your June 1961 issue that the I.S.O. regard watts and volt-amperes as possessing the same dimensions.

Would it be impertinent for a mechanical engineer to suggest that j, which relates the two sets of units algebraically (as my electrical friends tell me), is always a 'change of dimension' factor? To describe an inductive system, W and VA must be given, just as in any two-dimensional system longitude and latitude must be specified. Individually, each might be measured in the same units—feet or miles—but *in relation to each other* something corresponding to a vector or a j must qualify one of them. And nobody, I hope, would describe latitude and longitude as the same dimension.

Impedance being a two-dimensional concept, I suggest that the true equation resulting from dimensional analysis would read: $1\,\text{VA} = 1\,\text{W} + xj\text{W}$.—Yours faithfully,

E. G. SEMLER

The Chartered Mechanical Engineer
1 Birdcage Walk
5th July 1961 London S.W.1

Dear Sir—There is an unfortunate usage, common among most English-speaking engineers, which is expressed in the heading 'Watts and vars'.

This unfortunate usage, referring, in a somewhat 'popular' way, for example, to 'vars = watts $\times$ tan ϕ' instead of 'reactive power = active power $\times$ tan ϕ', immediately leads to the dangerous conclusion that what holds for the plural must also hold for unity.

1 var is the unit of reactive power. If we realize that it is a kind of power, its unit has to be 1 watt. But as it is a power that is constituted by an oscillation of energy, it has been found practicable to give this unit another name. Therefore it is right to say that 1 var = 1 W. There is no factor but unity connecting these two units of power. The factor tan ϕ of the above formula gives the connection between the quantities of active and reactive power of a given system. In geometry this would, for instance, mean the relation of the circumference of a circle to its diameter, i.e. π. Although one would be obliged to use different instruments for measuring these 'quantities', no one would argue that 1 yard of circumference is π times as long as 1 yard of diameter.

I hope sincerely that all is right with those scientists who represent their countries on the I.S.O., as well as with the theory of dimensions.—Yours faithfully,

KARL SAILER

Vienna
10th July 1961 Austria

DEPRECIATION OF ENGINEERING PLANT

Dear Sir—The article in the May 1961 *Journal*, p. 302, contained two statements: (a) that the annual cost of electricity supply in a certain year (1948–49) equalled £3 10s./kW of station capacity +0·447d./kWh, and that the coefficients were the same for every non-obsolete station in that year; and (b) that inflation or deflation has only a minor effect on real depreciation provision, which should therefore be based on historic not replacement cost.

However unimpeachable the mathematics by which these two statements were derived, the conclusions are highly questionable. Taking statement (a), the first part (kW charge) can be true only on the basis of a particular theory of depreciation provision that has in fact been designed so as to make it true. The second part (kWh charge) can be true only if the sets are loaded onto the system according to some specific plan, e.g. on the basis of efficiency merit. Otherwise the statement amounts to saying that the running costs of efficient and inefficient stations are the same.

The second statement is true only if the rate of interest fully discounts the effects of inflation or deflation, which it rarely does. Consider the highly simplified case of an asset affected only by physical depreciation (i.e. no obsolescence), so that at the end of its life it is replaced by an identical asset. If the rate of interest is fixed (in money, not in real, terms), then, if there is no inflation or deflation, the new asset will cost the same as the old, but, if there is inflation, the new asset will cost more and provision on a historic-cost basis will *not* be adequate.—Yours, etc.,

D. J. BOLTON

20 Basing Hill
17th June 1961 London N.W.11

[The article to which Mr. Bolton refers was based on a Supply Section paper 'A general theory of depreciation of engineering plant' by D. Rudd, B.SC.(ENG.), A.M.I.MECH.E., ASSOCIATE MEMBER, which was read at a meeting of the Section at Savoy Place on the 15th February 1961 (see May 1961 *Journal*, p. 328). Mr. Rudd writes: The truth of the whole of statement (a), not merely the first part, depends on the adoption of the general theory of depreciation. The article was quite explicit on that point, but the theory was not designed to make the statement true. Again, the whole statement, not merely the second part, depends on the actual practice in the supply industry of bringing the generating stations into operation in merit order as the demand increases and shutting them down in the reverse order as the demand decreases. This practice was explained in my paper. In its context therefore the statement is true.

In the second statement, by substituting 'therefore' for 'furthermore', Mr. Bolton has somewhat confused the sense of what I said. However, the point he makes was raised at the discussion of my paper in London, and my reply will be printed, I understand, in the *Proceedings* in October.]

VOTING PROCEDURE

Dear Sir—The voting procedure in Institution elections is, if anything, even more unsatisfactory than Mr. G. I. Thomas describes (June 1961 *Journal*, p. 367). The very mechanics of striking out candidates' names must lead to voters considering not who are the most suitable candidates, but who are the least suitable.

Unless personal knowledge is used to supplement the brief biographical details of the candidates sent with the ballot paper, there is a grossly inadequate amount of information available to help voters in assessing the merits of the candidates. In a postal ballot conducted with a widely scattered electorate of 25000 or so, personal knowledge of unofficial candidates is likely to be unusual. The natural tendency is for those voting to accept the backing of the Council for its nominees, perhaps equally unknown.

Because these factors will still operate, even with the beneficial changes proposed by Mr. Thomas, I think that a more drastic revision of the method of election is necessary.

I suggest, first, that the elections be conducted using the principles of the single transferable vote and quota counting; and, secondly, that, in addition to the brief biographical details, the ballot papers be accompanied by short explanatory statements written by the individual candidates.

In this way the voting mechanics become a matter of numbering the candidates in order of preference, starting with the best, and the voter would have greater assistance in deciding his preferences.—Yours faithfully,

SELWYN PALMER

25 Essex Road
23rd June 1961 Barnton, Edinburgh 4

Dear Sir—Mr. G. I. Thomas (June 1961 *Journal*, p. 367) has raised a very interesting point, and one wonders if there is any considerable feeling among the membership in favour of a change of procedure. One objection to Mr. Thomas's proposed solution is that under it there would be a possibility (albeit a very remote one) that not enough candidates would be elected to fill the vacancies!

Your editorial note sets out the present position but does not give any indication of official opinion. Presumably any change would entail alterations to the Bye-laws. Can the Council make a statement of policy in this matter, or is it considered that it should be raised at the Annual General Meeting?—Yours faithfully,

J. C. TURNBULL

Levenbank, High Street
Great Ayton
4th July 1961 Middlesbrough, Yorks.

[The suggestions in the letters of Mr. G. I. Thomas, Mr. Selwyn Palmer and Cmdr. J. C. Turnbull have been noted for reference to the responsible committee of the Council when the next general review of the Bye-laws is undertaken —Secretary I.E.E.]

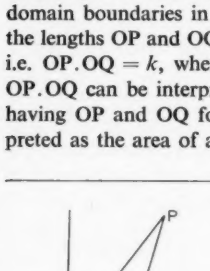
INVERSION AND CONTOUR PLOTTING

Dear Sir—Recently, in solving some infinite-boundary-potential problems by relaxation, I used the transformation $w = 1/z$, where $w = u + jv$ and $z = x + jy$, to transform

the original problem in the z-plane into one having finite boundaries in the w-plane. When the solution was obtained, i.e. all the required equipotentials were plotted in the w-plane,* I was faced with the problem of transferring the solutions from the w-plane to the z-plane. The obvious method of using the relations $x = u/(u^2 + v^2)$ and $y = -v/(u^2 + v^2)$, while satisfactory when only a few points are involved, is very tedious when equipotentials for a complete solution have to be transferred. I therefore devised a geometrical method based on the polar forms $z = r \angle \theta$, where $|r| = |z|$ and $\theta = \tan^{-1} y/x$, and $w = \rho \angle \phi$, where $|\rho| = |w|$ and $\phi = \tan^{-1} v/u$, which may be of interest to other members.

1

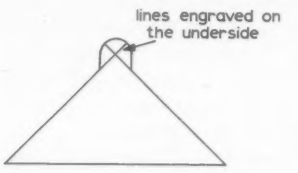
From the polar forms it follows that $\rho = 1/r$ and $\phi = -\theta$, so that $w = (1/r) \angle \overline{\theta}$. If, therefore, P is a point (r, θ) in the z-plane, its inversion Q is a point $(1/r, -\theta)$ in the w-plane; Fig. 1 shows this graphically. In practice, it is usually necessary to introduce a scale factor when drawing the domain boundaries in the two planes. In general, therefore, the lengths OP and OQ in Fig. 1 are related by $OQ = k/OP$, i.e. $OP.OQ = k$, where k is the scale factor. The product OP.OQ can be interpreted as being the area of a rectangle having OP and OQ for its sides. Similarly, k can be interpreted as the area of a square, of side $\sqrt{k}$, equal in area to the rectangle OP.OQ. This interpretation forms the basis for the geometrical construction of inversion.



2

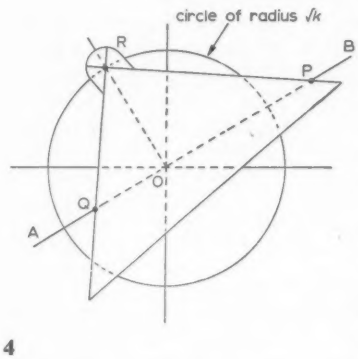
Suppose it is required to find the inversion of some point P (Fig. 2); we proceed thus: join PO; erect at O a perpendicular OR, of length $\sqrt{k}$, to PO; erect at R a perpendicular to PR; produce it to meet PO produced at Q; Q is then the 'mirror image' of the true inversion of P. This is easily verified from the geometry of Fig. 2.

This construction could be used for all the points that have to be inverted, but it would be found that, as the number of points treated increased, so, also, would the confusion due to the network of construction lines. This can be avoided by using the set square illustrated in Fig. 3. It is not essential that this special set square be used; any set square will do; but the sighting device ensures accurate point location and greatly facilitates plotting. The set square is used as follows.



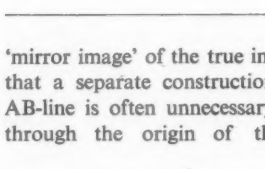
3

Cover the accurately drawn equipotential plot in the w-plane with a sheet of tracing-paper: all construction lines and the final equipotential plot in the z-plane are carried out on this sheet. With the origin O (Fig. 4) of the w-plane as centre, draw a circle of radius $\sqrt{k}$ units. Next, draw a straight line AB through O and the point to be inverted P and erect a perpendicular to this line at O. This perpendicular will intersect the $\sqrt{k}$-circle at a point R (corresponding to R in Fig. 2). It only remains now to fix the point R in the sighting device of the set square and line up P (the point to be inverted) with one side of the set square; the intersection of the other side with the line AB locates the 'mirror image' of the true inversion of P. It should be noted that a separate construction for each perpendicular to an AB-line is often unnecessary, since a set of straight lines through the origin of the w-plane at 15° intervals usually provides sufficient pairs of mutually perpendicular lines.



4

In conclusion, I call attention to an elementary geometrical construction which is very convenient for determining $\sqrt{k}$. Draw $BC = (k + 1)$ units (Fig. 5); mark off $CA = 1$ unit; construct a semicircle on BC and erect a perpendicular at A to intersect this semicircle at X; $AX = \sqrt{k}$ units.—Yours faithfully,



5

H. McKIBBIN
Department of Electrical Engineering
The Nigerian College of Technology
Zaria Branch
Zaria, Nigeria

29th June 1961

* It is easier to plot the equipotentials on the regularly meshed net used in the w-plane

COSMIC ELECTRICAL DISCHARGES

4—THE ENERGY RADIATED BY RADIO GALAXIES

Dear Sir—Since the Russians recently remembered what J. J. Thomson said in 1897 about the radiation that would come from electrons moving in magnetic fields, the radio astronomers have been making a living by postulation, and seeing how far they can go without being caught out! Virtually all papers and lectures on the subject have started with the two sentences 'Let H = the magnetic field. Let mc^2 = the energy of the relativistic electrons'. In other words, the problem is solved by postulation before they start. Having thus obtained by postulation the two major requirements, which the electrical-discharge theory alone supplies, the rest is algebra and comparison of 'theory' and observation, so that one finishes with a neat little table of values corresponding to the different values of H that one has initially 'supposed' for oneself.

At first these values usually ranged from about 10^{-2} to 10^{-6} gauss, in order presumably to minimize the energy in the relativistic electrons. However, recent observations with the large radio telescopes have caught out the algebraists, for no evidence has been found for magnetic fields greater than at most 5×10^{-6} gauss.

The great difficulty has been to account for the huge amount of energy radiated by radio galaxies like that shown in the photograph in the first letter of this series,[1a] NGC 4486 —the radio source Virgo A. One can judge of the difficulty this energy presents to existing astrophysical theories from the suggestions put forward to account for it. For example, two astrophysicists wrote:[2] 'Astrophysicists have been at a loss to account for its extremely strong radiation, and it is tempting to suppose that the energy is coming from the galaxy's capture of a gob of anti-matter coming from an anti-galaxy.' However, in this, as in other fields, some are more easily tempted than others, and the theory that the 'jet' is a 'thermonuclear' electrical discharge[1a] would appear to offer a more likely solution.

Just recently[3] we have had another equally unlikely suggestion—that in galaxies like NGC 4486 exploding stars are in process of triggering off explosions in other stars. The suggestion conjures up a glorious galactic 'Brock's benefit night'! Even the more sober suggestion that the cause is the collision of two galaxies requires the postulate that somehow or other such a collision generates the necessary magnetic field as well as the relativistic electrons.

No such dire solutions are required, however, for the electric field and discharge theory can be shown to explain the amount of energy observed to be radiated by these galactic electrical discharges, which, it was suggested in the original account of this work,[1b] transform globular or elliptical galaxies into irregular or spiral galaxies. It may be recalled that this theory was put forward even before the discovery of radio astronomy, so that the latter discovery might almost be regarded as the fulfilment of a possible prediction of the theory, which the writer failed to make!

It was pointed out in a recent letter,[1c] and in a fuller account soon to appear,[1d] that the theory will probably account for the larger proportion (0·03) of heavy atoms in the Population I stars, as compared with that in the Population II stars (0·003). For the major difference between the gas which goes to the formation of the former population and that which originally went to the formation of Population II stars is that it has been subjected to 'thermonuclear' temperatures of about 400000000°K for a period of 10^7 or 10^8 years, a period determined by the distances involved and the velocity of propagation of the discharges.[1e] From the observed change effected by the discharge in the constituents of the gas that ultimately goes to the formation of Population I stars, we can therefore estimate the thermonuclear energy liberated during the discharge.

The mass of an average galaxy is that of about 10^{10} suns, and the mass of the sun is about 2×10^{33}g, so that the total mass involved in the discharge will be of the order of 10^{43}g. During the transformation of four atoms into one atom of helium, there is a loss in weight of the order of 10^{-2} of the original; and this, as we have just seen, occurs in a fraction of the order of 10^{-2} of the total number of atoms, so that the total amount of matter disappearing in the form of energy liberated will be of the order of 10^{39}g. The energy liberated, mc^2, will therefore be of the order of 10^{21} times this, or about 10^{60}ergs.

The total energy estimated[3] to be radiated from a radio galaxy during its life is 10^{58}ergs, in good agreement with our calculations, since this latter estimate is based on the rate of energy radiation from Virgo A, in which the discharges are at an early stage in their development, being a mere 300 parsecs (6000 million million miles) long, as compared with an average galactic diameter of 10 kiloparsecs. Conversely, this further agreement between theory and observation confirms the suggestion[1c] that these 'thermonuclear' electrical discharges are responsible for the observed difference in constitution of the gas that goes to the formation of the two stellar populations.

However, despite the continued success of the electric field and discharge theory in removing these and other major difficulties at present faced by astrophysicists, the shower of 'gobs of anti-matter' and detonating stars will doubtless continue, as it has done for the last 17 years.

When we in the E.R.A. began a new research, Mr. E. B. Wedmore decreed that we first make a critical résumé of published work. It is a programme that might well be followed by some academic circles, who, like Sir Henry Wood's 'cellist, seem to go on 'sawing away regardless'.—Yours faithfully,

C. E. R. BRUCE

The Electrical Research Association Laboratory
Cleeve Road
Leatherhead, Surrey

3rd July 1961

1 BRUCE, C. E. R.:
(a) *Journal I.E.E.*, 1958, **4**, p. 669
(b) 'A new approach in astrophysics and cosmogony (London, **1944**)
(c) *Nature*, 1960, **187**, p. 865
(d) *Journal of the Franklin Institute* (in the press)
(e) *Journal I.E.E.*, 1959, **6**, p. 315
2 HOYLE, F., and BURBIDGE, G. R.: *Scientific American*, 1958, **198**, p. 34
3 BURBIDGE, G. R.: *Nature*, 1961, **190**, p. 1053

THE 26th GENERAL MEETING OF THE I.E.C. AT INTERLAKEN

THE biggest-ever General Meeting of the International Electrotechnical Commission took place at Interlaken, Switzerland, from the 19th to 30th June 1961. About 950 delegates from 28 countries attended the meetings of 48 committees, including the Council and the Committee of Action.

The largest delegation was that from the United Kingdom; it was 136 strong, and was led by Mr. J. O. Knowles (Chairman of the British National Committee) and Mr. H. A. R. Binney (Director of the British Standards Institution). The next largest delegations were from Germany (112) and France (111). Japan and Russia were well represented with 37 and 22 delegates respectively.

Opening session

At the opening session on the 19th June the delegates were welcomed by Dr. P. Waldvogel (President of the Swiss Electrotechnical Committee) and by the Mayor of Interlaken. Then followed the 7th Charles le Maistre Memorial Lecture, which was delivered by Shri M. Hayath (Chairman of the Indian National Committee of the I.E.C.), who took as his subject 'What the I.E.C. means to the developing countries'.

As a result of the technical meetings, 24 documents were approved for publication as I.E.C. Recommendations and 74 documents were approved for circulation under the 'six months' rule'. These documents covered a very wide field, as will be appreciated from the following titles of the committees that produced them: graphical symbols for general electrical engineering and telecommunications; hydraulic turbines; voltages, current ratings and frequencies; electric traction equipment; insulating oils; radio transmitting equipment; measuring instruments and meters; power transformers; electrical installations in ships*; electric cables; mercury-arc rectifiers; insulation co-ordination; electro-acoustics*; power capacitors; lamps and related equipment; lightning arresters; instrument transformers; electronic tubes and valves; capacitors and resistors; protective relays; electrical equipment of machine tools; cables and wires for telecommunication equipment; semiconductor devices; ferromagnetic materials.

Committee of Action

The Committee of Action met on the 23rd June under the chairmanship of the President (Dr. I. Herlitz, Sweden). The Treasurer, Dr. A. Roth (Switzerland) presented the accounts for 1960, showing an income of 510000 Sw.fr. from subscriptions from the National Committees, and 119000 Sw.fr. from the sale of publications. The total expenditure during the year was 612000 Sw.fr., the working surplus thus being 17000 Sw.fr., compared with the estimated surplus of 49000 Sw.fr.

The committee confirmed the appointment of the United States National Committee as secretariat for the new Technical Committee on Computers and Data-Processing Equipment. The United States also provides the secretariat for an I.S.O. committee covering a similar field, and this common secretariat will ensure that there is no undue overlapping of the work of the two committees.

A working group composed of Secretaries of National Committees and officers of the Central Office was set up to review the directives for the conduct of the work of committees.

Because of the large amount of work at present in hand, the President called attention to the necessity for ensuring that new work was started only when it was clearly established that it would have the full support of the National Committees. On these grounds he proposed, and it was agreed, that no immediate action should be taken on a proposal to set up a new technical committee on dust-tight enclosures, but that the National Committees should consider the proposals already made by the Sub-Committee on Low-Voltage Switchgear in order to see whether these proposals could be adapted for wider application.

Brief consideration was given to a memorandum submitted by the Australian National Committee urging that the I.E.C. should give greater emphasis to safety matters. In this connection, it was recalled that the importance of writing safety clauses into I.E.C. Recommendations whenever possible had been recognized some five years ago by the setting up of a Sub-Committee on Safety, the status of this Sub-Committee being later raised to that of an Advisory Committee to the Committee of Action. It was agreed that the Australian memorandum should be referred to the National Committees in order that they could consider how the objectives of the I.E.C. on safety measures could best be achieved.

Council

The Council met on the 30th June in the medieval castle at Spiez, with Dr. Herlitz (President) in the chair.

Greece and Venezuela were elected to membership of the I.E.C., thus bringing the total membership to 36 countries.

An *ad hoc* working group was set up to review the statutes of the I.E.C. and to submit proposals for any revision that might be considered necessary. The formation of this working group arose from a proposal that the size of the Committee of Action (at present limited to nine countries) should be increased.

The Treasurer (Dr. A. Roth, Switzerland) introduced the budget for 1962 and pointed out that the expenses of the Central Office tended to double every 4½ years. The only practicable way of balancing the budget was, apart from restricting the work of the Commission, to increase the subscriptions from the National Committees, and he proposed an increase of 40% for 1962 and 1963. (The present United Kingdom contribution is 43200 Sw.fr., about £3600).

There was general agreement that it was undesirable to restrict the work of the I.E.C., and although various suggestions were made for reducing the expenses of the Central Office, it was agreed that all National Committees should be asked to increase their subscriptions by 40%.

Elections

Dr. Herlitz (Sweden), having served a term of office of three years as President, was not eligible for re-election, and Prof. G. de Zoeten (Netherlands) was elected as the new President. Prof. de Zoeten has been actively associated with I.E.C. work for about 30 years, and the only regret expressed at his election as President was that he would have to resign the chairmanship of the Technical Committee on Switchgear. Dr. A. Roth (Switzerland), being eligible for re-election, was elected Treasurer for a further period of three years.

Japan, Romania, and the United Kingdom were elected to the Committee of Action to fill the vacancies caused by the retirement of India, Netherlands and Norway.

J. F. STANLEY

* These Committees met in Stockholm and Helsinki just before the meetings at Interlaken, but the results of their work were reported to the Committee of Action at Interlaken

The article in this regular monthly feature is based on a current paper read at an Institution meeting. It is written by the author of the paper, who has been asked to make the article, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the article brings out the main points and conclusions of the paper, its content is not necessarily confined to the subject-matter of the original paper

SIGNAL-GENERATOR CALIBRATION

A short account based on a Measurement and Control Section paper (3356) 'The concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration' by D. Woods, Associate Member. The paper was published in Part B of the Proceedings, vol. 108, p. 37. It was read before a joint meeting of the Measurement and Control and the Electronics and Communications Sections at Savoy Place on the 11th April 1961 (see p. 532). The author is at the Ministry of Aviation.

SIGNAL generators are in widespread use for measuring the sensitivity of r.f. receivers in the approximate range 30kc/s–30Gc/s. A signal generator comprises a screened r.f. source supplying a calibrated attenuator, the input to which is normally monitored at a constant level. The setting of the attenuator determines the magnitude of the signal at the outlet, which can be either coaxial or waveguide. The signal amplitude can be expressed in terms of either voltage or power.

The source impedance of a signal generator is normally designed to be equal to the nominal impedance of the system on which measurements are made, and it is usually 50Ω for coaxial systems or the wave impedance of the associated waveguide. Because the source and load impedances are substantially equal, any departure of the signal-generator source impedance from the nominal value will result in an error in the amplitude of the signal delivered to the load. Source voltage standing-wave ratios (v.s.w.r.) of between 0·5 and 0·7 are typical of signal generators in current use.

The error due to source-impedance variation could, of course, be corrected, but this would require a complete knowledge of the impedance/frequency characteristics of both the source and the load. The application of corrections in this manner would be a very tedious procedure and quite unacceptable for routine work. In practice, therefore, one is forced to assume that the source impedance is constant and equal to the nominal value.

Calibration of output level

This raises the question whether there is some optimum way of calibrating the output level so as to minimize the error in load voltage or power caused by source-impedance variation. It has been found that errors due to this cause can be reduced considerably by adopting the concepts of equivalent source e.m.f. or equivalent available power. They are defined as follows:

Equivalent source e.m.f. is twice the voltage produced across a resistive load equal to the nominal source impedance

Equivalent available power is the power dissipated in a resistive load equal to the nominal source impedance.

The two concepts are compatible in that a signal generator calibrated by either method will lead to the same estimate of the power dissipated in any load impedance.

It is normal practice to calibrate the output voltage or power in two stages. The output is first calibrated at a convenient fixed level, called the calibration level, by means of a voltmeter or wattmeter. Secondly, the attenuator is calibrated in relation to the fixed level by means of a standard attenuator. In this way the output level at all settings of the attenuator is established.

Methods of establishing the calibration level

There are three common methods for establishing the calibration level, namely:

(a) Measurement of the source e.m.f., i.e. the open-circuit voltage

(b) Measurement of available power, i.e. the power delivered to a conjugate-matched load

(c) Measurement of the voltage produced across a resistive load equal to the nominal source impedance.

Method (c) is the one that leads to the concepts of equivalent source e.m.f. and equivalent available power.

Comparison of the calibration methods

Consider a perfect signal generator having a source impedance equal to the nominal characteristic impedance of the system and an imperfect signal generator having a source reflection coefficient ρ_s. Let the imperfect signal generator be calibrated in three ways by methods (a), (b) and (c) and connected in turn to an arbitrary load impedance of reflection coefficient ρ_L across which voltages V_{La}, V_{Lb} and V_{Lc} are produced. The merits of the three methods can now be compared in terms of the moduli of the ratios of these voltages to that, V_{Ln}, produced by the perfect signal generator. The expressions obtained are:

method (a) $$\left|\frac{V_{La}}{V_{Ln}}\right| = \frac{|1-\rho_s|}{|1-\rho_s\rho_L|} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Paper read (continued)

method (b) $$\left|\frac{V_{Lb}}{V_{Ln}}\right| = \frac{(1 - |\rho_s|^2)^{1/2}}{|1-\rho_s\rho_L|} \quad . \quad . \quad . \quad . \quad (2)$$

method (c) $$\left|\frac{V_{Lc}}{V_{Ln}}\right| = \frac{1}{|1 - \rho_s\rho_L|} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

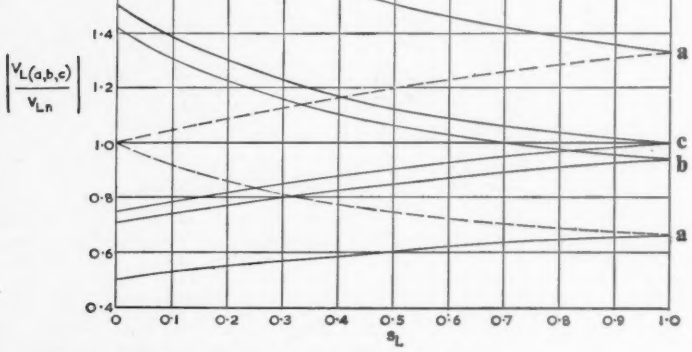
It is not possible to plot these expressions, because ρ_s and ρ_L are complex quantities. However, by assigning phase angles to ρ_s and ρ_L for the worst conditions, it is possible to obtain minimum and maximum values in terms of the v.s.w.r.s, S_s and S_L, of the source and load. This leads to the following expressions:

$$\left|\frac{V_{La}}{V_{Ln}}\right|_{min} = \frac{S_s(1 + S_L)}{1 + S_sS_L} \qquad \left|\frac{V_{La}}{V_{Ln}}\right|_{max} = \frac{1 + S_L}{S_s + S_L} \quad . \quad (4)$$

$$\left|\frac{V_{Lb}}{V_{Ln}}\right|_{min} = \frac{\sqrt{S_s}(1 + S_L)}{1 + S_sS_L} \qquad \left|\frac{V_{Lb}}{V_{Ln}}\right|_{max} = \frac{\sqrt{S_s}(1 + S_L)}{S_s + S_L} \quad . \quad (5)$$

$$\left|\frac{V_{Lc}}{V_{Ln}}\right|_{min} = \frac{(1 + S_s)(1 + S_L)}{2(1 + S_sS_L)} \qquad \left|\frac{V_{Lc}}{V_{Ln}}\right|_{max} = \frac{(1 + S_s)(1 + S_L)}{2(S_s + S_L)} \quad (6)$$

These expressions are plotted in Fig. 1, from which it is apparent that method (c) produces the minimum error. Furthermore it is the only method that produces zero error, $\left|\frac{V_{Lc}}{V_{Ln}}\right| = 1{\cdot}0$, for any value of S_s for $S_L = 1{\cdot}0$, because this is the condition of calibration.



1 *Minimum and maximum values of load-voltage ratio*
a $|V_{La}/V_{Ln}|$ source-e.m.f. method (a)
b $|V_{Lb}/V_{Ln}|$ available-power method (b)
c $|V_{Lc}/V_{Ln}|$ terminated method (c)

As a further example of method (c), if both the source and load impedances are, say, 20% in error ($S_s = S_L = 0{\cdot}8$), the voltage across the load will only be about 1% in error compared with that which would be produced by a perfect signal generator.

The calibrating instrument

An instrument to measure equivalent source e.m.f. or equivalent available power must present a good match to the nominal characteristic impedance of the system. For this reason it is possible to combine the dual functions of voltage and power measurement in the same instrument. Such an instrument, developed for this purpose, covers the complete r.f. spectrum up to 1000 Mc/s with a v.s.w.r. of 0·995. The inaccuracies on voltage and power measurement are 0·5 and 1·5% respectively.

Conclusions

The concepts of equivalent source e.m.f. and equivalent available power are necessary only when the source impedance is not equal to the nominal value and it is impracticable to apply corrections. Once a generator has been so calibrated, it is not necessary to retain either of these concepts. The generator can then be considered as having a true source e.m.f. or true available power, as established by this method, and a constant source impedance equal to the nominal value.

Because source-impedance variation causes a small error in the load voltage even when the calibration level is established by this method, it is clear that a suitable tolerance must be assigned to this parameter in addition to those on the calibration level and the attenuator. It is considered that these three tolerances should be such that each contributes equally to the over-all error on the load voltage in the worst condition, i.e. $S_L = 0$. For example, consider a generator of such accuracy that the voltage produced across a load of any value is not to be in error by more than 3% compared with a perfect generator; then 1% would be allowed on the calibration level 0·1 dB on the attenuator, and the v.s.w.r. of the source would have to be not less than 0·98 [eqn. (6)].

By adopting the foregoing method for establishing the calibration level, the impedance/frequency characteristic of the source need be verified only once, i.e. it can be treated as a type test and thereafter ignored provided that it is within the permissible tolerance in all conditions.

The above analysis has been carried out with coaxial systems in mind and in terms of voltage ratios for comparison purposes. However, the results are equally applicable to waveguide systems where the power concept is more appropriate. The voltage ratios given by eqns. (4)–(6) can be converted to power ratios, in terms of v.s.w.r.s, simply by squaring them.

621.317.312.029:621.373.42

In this monthly section are summaries of papers published in the *Proceedings* of The Institution that have not been read at Institution meetings. They are included primarily for reference. Reprints, price 2s., become available about two months after publication

Automatic check synchronizing equipment

A summary of a Supply Section paper (3567) 'Automatic check synchronizing equipment using static relaying principles' by Colin Adamson, D.Sc., M.Sc.(Eng.), Associate Member, and O-P. Mosland, M.Sc.Tech. The paper is published this month in Part A of the Proceedings. The authors are at the Power Systems Laboratory, Department of Electrical Engineering, Manchester College of Science and Technology.

THE authors describe circuit arrangements for automatic check synchronizing equipment employing static relaying principles that have already been used with success in the field of protective gear. Existing commercial equipment is not entirely static, nor is any attempt being made so far to utilize the properties of transistors in this particular field. The authors show that all the necessary functions of voltage regulation and phase and slip measurement can be carried out successfully using these elements and principles.

Representative test results and a summary of performance are included. 621.316.729:621.318.57

Random pulse generator

A summary of a Measurement and Control Section paper (3612) 'A random pulse generator with variable mean rate' by J. L. Douce, M.Sc., Ph.D., Graduate, and B. G. Leary, B.E., Associate Member. The paper will be published in Part B of the Proceedings. The authors are in the Electrical Engineering Department, Queen's University, Belfast.

THE authors describe the methods by which a random pulse train with predetermined statistical properties may be produced. It is required that the mean pulse rate be variable over a wide range and that the probability of a pulse occurring at any instant be independent of the previous history of the pulse train. This second condition is satisfied if the time of occurrence of the pulses obeys the Poisson distribution, and several methods of realizing this distribution are investigated.

The most satisfactory practical means of obtaining the required pulse train is found to be the sampling of a random signal, an output pulse being given whenever the random signal exceeds a predetermined amplitude. The theoretical requirements are discussed, and the circuit techniques are presented. Automatic control of mean rate is incorporated in the device described. 621.374.44 : 621.391 : 621–52

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monograph as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Effects of eddy currents on the rise and decay of flux in solid magnetic cores

Monograph 463U

PROF. N. KESAVAMURTHY, M.A., B.E., M.SC.TECH., *and* P. K. RAJAGOPALAN, B.E., M.S., PH.D.

RIGOROUS analysis of the transient behaviour of a solid-cored magnetic circuit of rectangular section, taking into account the resistance of the magnetizing winding, is difficult to obtain and has not been attempted so far in the literature. An attempt is made by the authors to obtain, to a close degree of approximation, the transient behaviour of cores of such sections. It is shown that the complexities of the problem can be reduced by choosing certain contours of constant current density, and, on this basis, four alternative solutions are obtained for the transient behaviour. These contours are justified on the basis of (a) flux decay with the magnetizing winding open and (b) eddy-current loss due to alternating flux. Rigorous solutions for the two cases are available for comparison. The analysis is illustrated by a specific application to the rise of flux due to an impact excitation on a solid core, and certain conclusions are reached.

In the majority of cases, the results are presented in a non-dimensional form.

Monographs (continued)

A direct procedure for the synthesis of resistive $(n+1)$-poles

Monograph 464E

P. P. CIVALLERI, DOTT.ING.

THE author deals with the problem of the realization of a real nth-order square symmetrical matrix as the conductance matrix of a resistive n-port based on a network of $(n+1)$ nodes.

The technique of synthesis starts with the construction of a tree of the independent voltages along well known lines, by inspecting the sign pattern in the given matrix. It is shown that, at each stage of this realization process, one can also determine the branch conductances that have to be connected in order to fulfil the requirements of the given matrix, thus entirely realizing the synthesis procedure.

The advantage of this method is that it does not require long algebraic computations in the final steps of the synthesis.

The branch-conductance synthesis technique is entirely based on some intuitive analysis theorems.

A proof of the topological rules of signal-flow-graph analysis

Monograph 465E

A. NATHAN, E.E., M.S., D.SC.(ENG.)

THE topological rules for the calculation of a signal-flow-graph transmittance are usually proved by quite a lengthy *ad hoc* argument. This is neither necessary nor advantageous, because a straightforward matrix analysis of the problem leads directly to the desired result. Such an analysis is given by the author.

A note on the analysis of the fields of line currents and charges

Monograph 466

P. J. LAWRENSON, M.SC.

THE method of images is widely used in the analysis of fields due to currents and charges, but it is of limited application and a more general method is required. The author shows that, for the analysis of 2-dimensional fields due to linear filaments of current or charge, conformal-transformation methods can be used simply for a very wide range of problems. The only requirement is the determination of an equation (or a series of equations) that transforms a straight line into the shape of the boundary of the field. The boundary types that can be treated simply are equipotential and flux line, and combinations of the two. The necessary basic field solutions for each of these three types, for fields interior and exterior to given boundaries, are developed.

Use of the method is demonstrated by two examples involving simple polygonal boundaries. The first is a determination of the error caused by treating a finite boundary as if it were infinite (an approximation frequently necessary when the image method is used). The second is an estimation of the inductance of a conductor carrying h.f. current and influenced by a conducting surface. A method of estimating the inductance of a current influenced by permeable bodies is also mentioned.

The use of tensor densities in equivalent circuits for field problems

Monograph 467E

J. W. LYNN, M.SC., PH.D.

EQUIVALENT electrical networks to represent fields described by certain partial differential equations have for many years been used as a standard analogue technique. In these networks, the dependent and independent variables are usually represented by voltage drop and currents in the branches ('across' and 'through' variables), and these analogue quantities on the network give the distribution of the field.

In setting up equivalent networks for this purpose, Kron added two steps to the existing concepts, namely (a) he derived circuits in terms of general co-ordinates, the topology of each network being independent of the co-ordinate system chosen, and (b) by applying Stokes's theorem to the system of vectors he showed that the networks thus derived could be interpreted as containing the field quantities flowing in the filled space. The quantities measured on the network then correspond to line, surface or volume integrals of the vector-field quantities. With this interpretation, the networks become more realistic models of the fields, since the whole space is filled and the choice of co-ordinate system does not affect the physics of the phenomena.

The author describes the mathematical basis of this fuller interpretation of analogue networks.

THE JOURNAL DIGEST | IN THE PROCEEDINGS

The date in italics is that of the Journal review, special article or summary. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (AUGUST 1961)

A. J. BLUNDELL, A. E. GARSIDE, B.SC.(ENG.), R. G. HIBBERD, B.SC., *and* I. WILLIAMS, B.SC. PAPER 3362U, NOVEMBER 1960 **Silicon power rectifiers** *April 1961*

E. KUFFEL, M.SC., PH.D. PAPER 3322M, FEBRUARY 1961 **Influence of humidity on the breakdown voltage of sphere-gaps and uniform-field gaps** *June 1961*

E. KUFFEL, M.SC., PH.D., *and* A. S. HUSBANDS, B.SC.(ENG.). PAPER 3371M, FEBRUARY 1961 **The influence of nearby earthed objects and of the polarity of the voltage on the direct-voltage breakdown of horizontal sphere-gaps** *June 1961*

E. KUFFEL, M.SC., PH.D. PAPER 3372M, FEBRUARY 1961 **The direct voltage calibration of air-gaps in a uniform field and between spheres up to 25cm in diameter** *June 1961*

A. E. GUILE, PH.D., B.SC.(ENG.). PAPER 3289S, JULY 1960 **The protection of high-voltage insulators from power-arc damage** *April 1961*

M. OUYANG, B.ENG., PH.D. PAPER 3641M **The mathematical basis of the absolute calibration of voltage dividers for the measurement of front-chopped impulse waves** *July 1961*

COLIN ADAMSON, D.SC., M.SC.(ENG.), *and* O-P. MOSLAND, M.SC.TECH. PAPER 3567 **Automatic check synchronizing equipment using static relaying principles** *August 1961*

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (JULY 1961)

See the Journal for July 1961, p. 452

PART C. MONOGRAPHS (MARCH 1961)

See the Journal for March 1961, p. 179

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

CHARLES VICKERY DRYSDALE

Charles Vickery Drysdale, C.B., O.B.E., D.SC., F.R.S.E., who died in retirement on the 7th February 1961 was born on the 8th July 1874 at Barnstaple, Devon. After private schooling he studied for two years at Finsbury Technical College, followed by three years at the Central Technical College at South Kensington, the forerunner of the City and Guilds College. He received diplomas in physics and engineering and the Siemens medal.

On leaving college Drysdale spent 15 months as experimental assistant with Nalder Brothers and Co. In 1896 he became chief assistant and senior lecturer in electrical engineering at Northampton Institute, London, a position that he held until 1910.

Having developed a lively interest in the design, making and use of scientific instruments, he then joined H. Tinsley and for six years devoted his time with enthusiasm to the practical side of the industry. Some of the instruments, such as the a.c. potentiometer and the polyphase wattmeter, gave him scope for work of a fundamental nature, as a result of which they have today become high-precision instruments. His contribution at this stage was largely the elimination of errors in changing over from d.c. to a.c. measurement. He later became a partner in the firm.

In 1918 he joined the Admiralty Research Laboratory at Parkeston Quay, where his extensive knowledge of a.c. theory and instrument design led him to produce the 'leader' cable system for guiding ships blindfold in crowded estuaries, the story of which is told in the *Philosophical Transactions* for 1924.

From Harwich via Shandon (1919–1921) and Teddington (superintendent, Admiralty Research Laboratory, 1921–1929), he progressed to the position of director of scientific research, Admiralty. He held this position from 1929 until he retired in 1934.

In 1920 he delivered the Kelvin Lecture at Savoy Place on 'Modern marine problems in war and peace', and four years later his valuable two-volume work on electrical measuring instruments, written in collaboration with A. C. Jolley, appeared. In 1928 and 1931 he wrote two important progress reviews on instrument practice for the *Journal*.

He had many interests outside his specialist field. As a young man he took a great interest in student life and technical education, as appears from two revealing addresses that he gave before the Students' Section of The Institution in 1914 and 1916.

He joined The Institution as a Student in 1892 and was elected an Associate in 1895 and a Member in 1902. He served as honorary secretary of the Students' Section in 1894. Eight of his papers were published in the *Journal* in 1902, 1910, 1914, 1917, 1928, 1930, 1931 and 1933 respectively. He was appointed an Officer of the Order of the British Empire in 1920 and a Companion of the Order of the Bath in 1933 P. D.

JOHN EDWIN INNES-CRUMP

Air Comm. John Innes-Crump, M.A., who was born on the 7th August 1914 died suddenly on the 19th April 1961. He was educated at Highgate School and at Merton College, Oxford. He joined the Reserve of Air Force Officers in 1934 and was granted a permanent commission as a pilot officer in the general duties branch in 1936.

After completing his pilot's training in 1936 he served for two years in bomber squadrons. He then attended a specialist signals course, which was followed by employment on signals duties with various units until 1941, when he went to Canada for a year. On his return he served in Fighter Command as a signals staff officer until he joined the directorate-general of signals in the Air Ministry in 1945, where he remained until 1946.

After attending a staff-college course, he served as a signals staff officer in Malaya, at Supreme H.Q. Allied Powers Europe, and at the Experimental Establishment, Boscombe Down. He then returned to flying duties, and after a jet conversion course he commanded the fighter operational training unit at Leeming, and then Pershore. His last appointment, for which he was promoted to air commodore, was director of air-staff briefing at the Air Ministry.

Although he became a signals specialist early in his career, he remained an active pilot, and it was a great disappointment to him when his flying had to be restricted on medical grounds. As an experienced signals officer who also had first-hand knowledge of flying high-performance aircraft, he was particularly well suited for the command of Pershore, an appointment that carried with it responsibility to the director of the Royal Radar Establishment for the flying needed in radar research and development. During this period he made many friends in Worcestershire, particularly through his keen interest in sailing and the R.A.F. Association.

He is survived by his widow and two daughters.

He joined The Institution as a Graduate in 1940 and was elected an Associate Member in 1945 and a Member in 1954. T. U. C. S.

GEORGE GWENDOWER LANGDON PREECE

George Gwendower Langdon Preece who died on the 12th September 1960 was born on the 4th March 1880 in London. Educated at Manchester Grammar School and receiving his technical training at Manchester School of Technology, he commenced in 1896 his practical training with W. T. Glover and Co., where he remained until 1910, then being engaged by Bruce Peebles and Co. Ltd. as an engineer in their Manchester office.

During the 1914–18 War he served in the Lancashire Fusiliers and in 1919 was appointed manager of Bruce Peebles's Manchester office, serving in that capacity until 1935. He was then appointed sales manager in Edinburgh. During the Second World War he was a most active member of the company's civil defence organization.

He retired in 1947 to Sidmouth, where he was able to enjoy his favourite recreation, golf. Unfortunately, for a few years before his death his sight had become progressively worse, and the time came when he could no longer participate in outdoor activities.

He was most lovable and had a host of friends, particularly in the electrical supply and manufacturing industries. He was a great 'personality salesman'. It is significant that the affection and respect in which he was held was nowhere more evident than among his competitors.

He is survived by his widow and a daughter, and no tribute to him would be complete without reference to the tremendous help and encouragement that he received in very full measure from his wife.

He joined The Institution as an Associate Member in 1903 and was elected a Member in 1931. He served on the North-Western Centre Committee from 1925 to 1935 and from 1940 to 1943, being vice-chairman from 1931 to 1933 and chairman in 1933–34. He was a member of the Institution of Mining Engineers and of the Association of Mining Electrical and Mechanical Engineers, having always taken a great interest in mining. W. B. L.

SYDNEY LOUIS RHYS PRICE

Sydney Louis Rhys Price who died on the 22nd March 1961 was born on the 18th September 1873. He was educated at Faraday House and received practical training with Yorkshire House-to-House Electrical Supply Co. and Robert Hammond and Son.

He joined Ayr Borough Electricity Works as chief assistant in 1896 and transferred to Pembroke Urban District Council, near Dublin, in 1900 as manager. He remained there until 1932, when Greater Dublin was formed and the P.U.D.C. undertaking was taken over by the Electricity Supply Board. He then retired on pension and became agent for a firm of Glasgow engineers. Owing to his wide experience and knowledge, his advice was greatly sought in the electrical field when problems arose.

He took a particularly keen interest in the Royal City of Dublin Hospital and on many occasions gave his advice and assistance freely, from goodness of heart. He continued to do so until the time of his death. He was also connected with the National Maternity Hospital, Dublin, and with Paul and Vincent Ltd.

In his earlier years he was very keen on fishing, golfing and gardening. He was a member of the Naturalists Club and an ornithologist, his collection of birds' eggs being quite a notable one. He is survived by a daughter.

He joined The Institution as an Associate Member in 1909 and was elected a Member in 1911. He served on the Dublin Local Section Committee from 1909 to 1913, being vice-chairman in 1910–11 and chairman in 1911–12, and on the Irish Centre Committee in 1920–21. J. McK.

SOME RECENT BOOKS

TRANSISTORS: PRINCIPLES, DESIGN AND APPLICATIONS

W. W. GÄRTNER

NEW YORK: VAN NOSTRAND. 1961. 675 PP. £4 14S.

DR. Gärtner has written what is probably the most ambitious single volume about transistors, being particularly thorough in deducing the properties of *p-n* junctions and of junction transistors from the key physical effects, in characterizing the transistor for the engineer, and in setting out, in considerable detail in many places, the design principles for a wide range of circuits handling sinusoidal signals. By comparison, the short section on the design of transistors sadly lacks precision and that on pulse circuits is less analytical and quantitative than much that precedes it: something could usefully have been said about the charge-control parameters and their application and a little more about the properties of modern mesa units at very high frequencies.

The text is, in turn, a manual for teachers, a designer's handbook and a reference work. In some places the detail required for reference purposes detracts from the educational value and in others may tend to obscure the assumptions on which the particular analysis or design is based. There are small points that may puzzle some readers: the curve for $I_B = 0$ is not included in the common-emitter d.c. characteristics (Fig. 8.11), kT is expressed in electron-volts to eight significant figures for 1°K steps of T from 1° to 500°K and thence for 10°K steps to 940°K, and the series conductance of a coil at low frequencies is said to drop proportionally to the number of turns and not to (number)^2.

But there is much in this book to commend it, particularly to electronic engineers who wish to get the best out of these versatile active devices. J. R. TILLMAN

ATOMIC ENERGY WASTE: ITS NATURE, USE AND DISPOSAL

E. GLUECKAUF (*Editor*)

BUTTERWORTHS. 1961. 420 PP. £4 15S.

IT is difficult to be completely objective about this volume, since many of the contributors are old friends and colleagues, and, certainly as far as this country is concerned, they are all leading experts. Even if I may be a little biased, therefore, let me say at once that this text seems to me to be quite excellent. It contains sufficient data to be considered as a work of reference, all written in a concise and authoritative fashion, and it is well produced and free from any obvious errors and omissions.

There is merit, too, in the orderly and systematic arrangement of the contributions, in which it is reasonable to see the work of the General Editor, Dr. Glueckauf. Even more one can see his influence in the attitude of mind behind the book, which is one that sees the need to study fission products so that they can be put to use for the benefit of mankind rather than to regard them as a dangerous nuisance. It is this thought that is sufficient to make a work that would in any case have been good into a really important volume. It can be thoroughly recommended and will repay very careful reading. L. ROTHERHAM

THE DYNAMIC BEHAVIOUR OF THERMOELECTRIC DEVICES

P. E. GRAY

JOHN WILEY. 1960. 136 PP. 28S.

THE subject-matter of this highly specialized book formed the basis of a doctoral thesis at the Massachusetts Institute of Technology. It contains a mathematical study of the transient behaviour of thermoelectric devices when subjected to step changes in one or other of several variables.

The cases are considered of a thermoelectric heat pump subjected to step changes in its operating current, its heat load or the temperature of its heat sink. Experimental measurements on a heat pump are described, and these are shown to be in reasonable agreement with the calculated transient behaviour.

The behaviour is also considered of a thermoelectric generator when this experiences step changes in its load resistance, load back-e.m.f., thermal input power, or temperature of its heat sink. No experimental correlation is attempted for the generator.

The text presents a series of formidable exercises in transformation calculus, yielding transfer functions that might be useful in the design of feedback control systems for thermoelectric devices. However, the development and application of these devices have not generally reached a sufficiently advanced stage for problems of stability of control to be of serious practical concern. P. B. CURTIS

THEORY OF MICROWAVE VALVES

S. D. GVOZDOVER

PERGAMON PRESS. 1961. 486 PP. £4

IN this translation from the original Russian, the author states that, since it is impossible to cover the whole field of microwave electronics in one volume, 'only the theory of those microwave devices which have found constant use in practice and the operation of which can be understood on the basis of one type of oscillation or wave is given in this book'. This stated object, together with the acknowledgment that the volume is complementary to a work by Lopukhin entitled 'Excitation of electromagnetic oscillations and waves by

electron beams', no doubt accounts for the, at first sight, rather surprising inclusions and omissions in the text.

Nearly half the book is devoted to the theory of plane diodes, which, though providing some introduction to electron dynamics, space-charge effects and noise phenomena at high frequencies, is not of the importance to microwave engineers that the length devoted to it would suggest. Subsequent chapters deal with high-frequency amplification by triodes, the reflex klystron, the travelling-wave tube, and the multicavity magnetron, together with a brief treatment of noise in travelling-wave tubes. There is little in these chapters that differs greatly from what is already to be found in the standard works on microwave valves, although what there is reasonably clearly presented and, moreover, well translated.

As one would expect, the majority of the references quoted are Russian, but none is later than 1952. The fact that nine years have elapsed since then also helps to account for many of the other important devices not being mentioned. The work is thus mainly of historical interest—apart from the collected chapters on the diode, which, despite the comment on their relevance, do form a useful collation of information.

For the student, although the matter presented is clear, the volume does not give a sufficiently up-to-date or balanced picture of the subject to be wholly satisfactory at present. To the valve engineer wishing to compare Western developments with those in the Soviet Union at the period when the book was current there, the translation will be of some interest even if it does have little new to offer. G. D. SIMS

MANAGEMENT TRAINING: AIMS AND METHODS

R. J. HACON

ENGLISH UNIVERSITIES PRESS. 1961. 253 PP. 17S. 6D.

THIS book attempts to bridge the gulf between management theory and practice, with special reference to training aspects. It is a very good attempt and constitutes a useful contribution, not only to management-training literature but also to management knowledge in general.

The first part deals with the training problem and the scope of training activities. The author stresses that training is a service to production and not an end in itself, that it seeks to overcome deficiencies in individuals and develop the potentialities of up-and-coming men and that it is, above all, continuous and progressive. While all these objectives are fundamental, the author could, with advantage, have dealt with the important contribution that training makes in the communication field, although reference is made to this aspect in other sections of the text.

The second part of the work covers the 'tools' of management training, and here it deals adequately with lectures, films and film strips, discussion-group leading, case-study and incident methods, role-playing and group development. The reader will derive much benefit from the extensive practical experience of the author in the application of the methods and techniques described.

In the third part, which is mainly theoretical, the author analyses the concepts of co-operation, leadership and continuity. He maintains that co-operation cannot be achieved unless (a) the group accomplishes the tasks set and (b) the individual's aspirations are satisfied. Leadership is considered from the aspects of creative adjustment, authority, the execution of orders and the reality principle. Reference is made to the work of Mary Parker Follett, Elton Mayo and others, but the important sociometric findings of Moreno are surprisingly omitted.

In the concluding chapters the author analyses management-training needs and the role of the trainer. He deals with 'new horizons in training', in which he emphasizes the needs to get away from the 'course mentality' and to use courses intelligently. Trends in project work using realistic factory situations with detailed working models, and 'T' group and other group-development methods, are described.

The volume is well written, although perhaps a little too much jargon is included, and it contains some excellent chapter summaries and explanatory diagrams. It will be especially useful to new entrants to the industrial training field and management departments of colleges, but it is also of sufficient importance to merit inclusion in the reference libraries of both specialist and general managers.

A. G. BEVERSTOCK

THE ELECTRON MICROSCOPE

M. E. HAINE (including a chapter written in collaboration with V. E. COSSLETT)

E. AND F. N. SPON. 1961. 282 PP. £2 15S.

TEXTBOOKS on electron microscopy are few, and this one raises high hopes. Dr. Haine has played an important part in the development of the British electron microscopes, and Dr. Cosslett is a leading authority, though his contribution to this work is confined to collaboration in a single comprehensive chapter on techniques and applications. It is a pity to have to record some disappointments.

Dr. Haine explains that 'mathematics have been excluded as far as possible and replaced by data. References are given but not comprehensively'. Within these limits, there are excellent sections on electron guns and the focusing of electron beams. Image formation is dealt with at considerable length and in an unconventional way, by considering the electron beam as a wave.

The non-mathematically minded may be disheartened here, especially as the hard-won results apply only to the contrast given by single atoms and so are 'possibly of little direct practical interest'. The usual approach, which treats the electrons as particles, would be simpler to follow and relates to practical specimens.

The chapter on design deals almost entirely with the EM6 electron microscope. Diagrams and pictures are numerous and excellent, but an odd lack is one showing a complete electron microscope. The uninitiated will be left wondering how the bits described all fit together.

The volume is a beautiful example of how a technical work should be printed. R. C. VALENTINE

HALBLEITER-BAUELEMENTE IN DER MESSTECHNIK—Vol. 7

BERLIN: VDE-VERLAG GMBH. 1961. 213 PP. DM18.

THIS is a publication of 12 lectures given at two meetings organized by the subsection on electrical and thermal measurement techniques of the V.D.E./V.D.I. There is a general introduction to semiconductor theory on a semi-popular level by H. Welker. The use of semiconductors for measuring purposes is studied by E. Arends, and detailed applications to instruments and circuits incorporating semiconductor diodes are considered by M. Sangl.

There follows a detailed discussion of the use of transistors in connection with amplifiers for measuring purposes, relays and regulated power supplies. The advantages and disadvantages of transistors for these applications are carefully examined, and conclusions are summarized in pictorial tables. Many circuits are indicated, and a variety of instruments of German manufacture are described.

There are lectures on thermoelectric, electromechanical and electro-optic transducers by Gravenhorst, Zobel and Kleiner. Particularly interesting are some chapters on the use of Hall generators in measurement techniques. It appears that German industry has pioneered a number of important instruments. This volume might be consulted by instrument users and manufacturers with much gain. H. MOTZ

TIME-HARMONIC ELECTROMAGNETIC FIELDS

R. F. HARRINGTON

McGRAW-HILL. 1961. 480 PP. £5 4S. 6D.

DURING the last year I have noticed the publication of several 'second generation' volumes on waveguides, by which I mean texts that go well beyond the elementary derivation of the fields, propagation constants, etc. of the waveguide modes that characterized several excellent textbooks issued during or just after the Second World War. The newer works make use of more-advanced mathematical techniques and, for example, treat problems of changes in cross-section, obstacles, etc. by a variety of methods, including the very powerful variational technique.

The present book is a useful addition to the range. It is more advanced and much more practical than Langmuir's 'Electromagnetic waves and fields', while it is less difficult and more inclusive (for example, it covers cavities and microwave networks) than Collin's 'Field theory of guided waves'. The author himself considers it to be designed for the first few years of graduate work, and one would be very happy if one sincerely believed that British first-degree courses reached the required level.

The text assembles problems requiring the same mathematical technique for their solution rather than using a division according to function. The first fifth is devoted to a revision of Maxwellian theory; then three long chapters, comprising about 40% of the number of pages, discuss planar, cylindrical and spherical wave functions. There are two chapters of about 60 pages each on perturbation and variation methods and on microwave networks. Mathematical appendixes deal with vector analysis and special functions. Many problems are worked through in detail to yield design curves, and there are more for practice.

The term 'time-harmonic' in the title is defined to mean 'steady-state' in the preface, and there is therefore no material on pulse propagation in dispersive media or similar questions. I found the publication very interesting and an excellent demonstration of the power of approximate analytical techniques in real problems. It can be recommended to anyone doing theoretical work on waveguides, aerials or cavities and their applications. A. H. W. BECK

ELECTRICAL AND MECHANICAL OSCILLATIONS

D. S. JONES

LONDON: ROUTLEDGE AND KEGAN PAUL. 1961. 104 PP. 5S.

THIS short text provides an introduction to the analysis of oscillatory systems having one degree of freedom. The work on mechanical systems includes free and forced oscillations, both damped and undamped, while in connection with electrical systems various circuit equations are treated and complex impedances receive attention.

This material is mainly familiar, involving few ideas beyond the range of those who have reached an H.N.C. level in mathematics, but an interesting chapter concerned with non-linear oscillations introduces more unusual work and, commencing with a section on phase-plane analysis, includes a treatment of slight non-linear damping, relaxation oscillations, and forced oscillations of non-linear damped systems.

Suitable worked examples and exercises are provided throughout the text, which will be of value for its clear presentation of the work selected from this important field.

F. H. JACKSON

AUDIO FREQUENCY ENGINEERING

E. HAYDN JONES

CHATTO AND WINDUS. 1961. 245 PP. £1 15S.

MANY textbooks originate as lecture notes, and the work under review owes its birth to a series at the Northern Polytechnic, where Mr. Jones is a senior lecturer in the Telecommunications Department.

The volume is divided into 12 chapters, the first being a résumé of essential mathematics and the second a discussion of the propagation of acoustic waves. Two further sections deal with the mechanism of speech and hearing and the characteristics of speech, music and noise, the remainder of the material covering measurement, disc, film and magnetic recording, microphones, loudspeakers and architectural acoustics.

This is a broad field to survey in 240 pages, and in consequence much of the subject is too lightly covered. The treatment is made even more tenuous by devoting 15 pages (the first chapter) to 'essential mathematics' and much of the

next 30 pages to the theory of vibrating strings, stretched membranes and pulsating spheres. Fifteen pages are insufficient to do more than remind the reader of the mathematical standard required, while the other subjects are of significant interest to the acoustic physicist but of only marginal importance to the audio engineer. The book contains no mention of inductors, capacitors, circuit theory, filter theory, transistors, amplifiers, rectifier circuits or iron-cored components, the basic tools of every audio engineer.

I noted a slip in the last paragraph dealing with tube measurement of absorption coefficient, where it is suggested that tube techniques give a lower value than chamber methods. As tube measurements confine the incident wave to the normal, they always give higher values than chamber or 'on site' measurements, where the figure obtained is an average value for all the angles of incidence characteristic of the location.

A list of some 20 references is given, but most of these are to other textbooks rather than to original papers. The printing and illustrations are excellent and the price very reasonable.

This is a publication for the serious worker rather than the hi-fi enthusiast and can be recommended to every audio engineer. J. MOIR

MATHEMATICAL HANDBOOK FOR SCIENTISTS AND ENGINEERS

G. A. KORN and T. M. KORN

McGRAW-HILL. 1961. 943 PP. £7 15S.

THE first question about a handbook is the standard of background knowledge that the reader must possess in order to use it. In this case a fair answer in present terms is probably somewhere between university entrance and an ordinary degree, though it should be added that, as exemplified by the definitions of vector operators, the approach is purely mathematical. At this level the reader may have to pursue all the back references from the topic he is seeking, but the information is all there, though in concise form.

As an example, it is possible for the reader who knows nothing of matrices to learn all the standard matrix manipulations from the text, noting references to earlier sections on the commutative field of scalars, determinants, etc. The book deals with a wide variety of topics, and the reviewer has been able to think of only one function that could not be found in the index (Rayleigh distribution). It includes a large set of tables of mathematical and statistical functions, of integrals, and of Fourier and Laplace transforms; the index is excellent.

D. A. BELL

EDISON

M. JOSEPHSON

EYRE AND SPOTTISWOODE. 1961. 511 PP. £2 2S.

THE rise of the electrical industry during the last 80 years is one of the most important and fascinating stories in the history of civilization. This book tells the story as seen through American eyes and particularly through the eyes of Thomas Edison, whose inventions laid the foundation of both the telegraph and the power industry in the United States.

As a character study the work is disappointing, and the author's comments on events are not very penetrating; nevertheless, this is a volume that should be read by all those who seek to understand and guide the electrical industry of our day. The author presents a mass of information about the interplay of finance and technology, including the exciting struggles that led to the formation of the American General Electric Company.

He shows how Edison achieved his great triumphs by building up an industrial research organization, which was the first of its kind in the world and which was held together by a sense of loyalty to the inventor in spite of the harsh treatment that he meted out to his staff. The book shows Edison's contempt for science and mathematics and his belief that the best method of research was trial and error; it shows him nevertheless employing one or two eminent mathematical physicists. In recounting both the successes and the failures of Edison's method, the author provides much food for thought. P. HAMMOND

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS—Vol. 13

L. MARTON (*Editor*)

NEW YORK: ACADEMIC PRESS. 1960. 454 PP. $13.50

THIS work contains five specialist review articles, prefaced by an editorial plea for criticism and suggestions from readers of the series.

'Inelastic collisions between atomic systems' by J. B. Hasted surveys the existing experimental and theoretical status of the subject. Collisions of this nature are of great interest and importance in many different fields, not least the thermonuclear one. 'Field ionization and field ion microscopy' by E. W. Müller is an interesting and valuable account of the potentialities of this important technique in solid-state investigations. P. A. Lindsay in 'Velocity distribution in electron streams' reviews theoretical analyses of the velocity spread in the flow of an electron stream in stationary electric and magnetic fields. Plane- and cylindrical-electrode systems and the plane magnetron are dealt with, and the article concludes by briefly comparing results of the idealized calculations with available experimental evidence.

The comparatively new technique of X-ray microanalysis, whereby sample volumes of about one cubic micron may be assessed from their X-ray emission spectra, is very fully treated by R. Castaing in 'Electron probe microanalysis'. The concluding article, 'Television camera tubes: a research review' by P. K. Weimer, emphasizes the principles of operation and performance of existing tubes, with some indication of future trends.

This volume should be available in all technical libraries and can be recommended to physicists or electrical engineers having a keen interest in any of the chapter subjects. It maintains the high standard of the series. V. ROBERTS

COMPLEX VARIABLES AND THE LAPLACE TRANSFORM FOR ENGINEERS

W. R. LePAGE

McGRAW-HILL. 1961. 475 PP. £4 17S.

THIS volume provides a stimulating presentation of work on the complex variable and the Laplace transform together with related topics, suitable for qualified engineers or advanced students who have gained some manipulative experience of these subjects and who wish to extend their knowledge of the basic theory.

The material on functions of a complex variable includes analytic functions, conformal mapping, Cauchy's integral theorem, Taylor's and Laurent's series, the residue theorem, analytic continuation and multivalued functions, while further useful results established lead to the Nyquist stability criterion.

Preparatory to the work on the Laplace transform, an important section deals with the validity of the inversion of the order of integration in iterated integrals having finite or infinite limits, while a chapter on the Fourier integral leads to a logical development of the Laplace-transform theory. This covers the shifting theorems, the transform of a derivative and an integral, the initial and final-value theorems, the convolution integral, and the inversion integral, including its evaluation when the integrand is multivalued.

The work in later sections includes the application of the Laplace transform to the solution of ordinary linear differential equations, an interesting treatment of the impulse function, periodic functions, and finally the Z-transformation, useful for the analysis of sampled-data systems. Adequate collections of examples for solution are included at the ends of the chapters.

The book will be of value for its comprehensive treatment of the mathematical foundation of a number of analytical processes important in engineering. F. H. JACKSON

LINEAR SYSTEMS ANALYSIS

P. E. PFEIFFER

McGRAW-HILL. 1961. 538 PP. £4 17S.

THE text aims to provide the reader with a sound understanding of circuit theory, with particular reference to linear control systems. It is patterned on a course given to undergraduate engineering students at Rice University in their fourth and fifth years, and provides a background to the more intensive treatment of specialized topics in other courses.

The volume opens with a chapter entitled (appropriately) 'A mathematical miscellany'. This summarizes some of the more important theorems on complex variables, rational functions, determinants, and integro-differential operators. The following three chapters are devoted to basic network theory, steady-state analysis, and an elementary introduction to Laplace-transform theory. The succeeding two sections establish the practical implications of these theorems through their application to a series of typical electrical and mechanical problems.

From chapter 8 onwards, a more advanced level is set. The following topics are discussed in some detail: mathematical properties of the Laplace transform, transfer-function analysis, matrices, signal flow-graphs, and negative feedback.

The book is well presented, and Prof. Pfeiffer expounds his subject clearly. Although mathematical, it is written essentially for engineers. Each chapter concludes with problems and a set of well selected references for further reading.

The shortcomings of the work are twofold. The first, consequent on the outlook and specialization of the author, is the almost complete omission of all aspects of circuit theory relating to the synthesis of 2- and 4-terminal networks. In the opinion of the reviewer, this would be of more benefit to the student than the section on signal flow-graphs, which is a somewhat specialized topic of debatable importance. The second shortcoming is the author's very occasional lapses into 'blackboardese', e.g. '$f(s)$ is p-r iffi $1/f(s)$ is p-r', which, for the benefit of the uninitiated, means—'$f(s)$ is a positive real function if, and only if, $f^{-1}(s)$ is a positive real function.'

In summary, this is an excellent book, iffi the reader wishes to specialize in control-system engineering. J. M. C. DUKES

ESSENTIALS OF DIELECTROMAGNETIC ENGINEERING

H. M. SCHLICKE

JOHN WILEY. 1961. 242 PP. £3 16S.

THE book, said by the author to be written for the 'inquisitive electronics engineer and advanced engineering student', deals with magnetically soft ferrites and high-permittivity dielectrics, all polycrystalline ceramic materials. There are similar features in the respective magnetic and electric behaviour of these two types of material in relation, for example, to frequency, temperature and anisotropy, and the author has therefore thought fit to apply the common term 'dielectromagnetic' to them.

Apart from some field and circuit theory, and a descriptive account of ferro- and ferrimagnetism, the text deals mainly with applications and the suitability of a number of ferrites and ferroelectric materials. Unfortunately, the great amount of technical data given applies to particular commercial products of American manufacture, with no indication of their chemical composition. This limits the value of the work to the inquisitive engineer, particularly if he is domiciled outside the United States. There is, however, a useful bibliography of relevant textbooks and papers. F. BRAILSFORD

AIRBORNE RADAR

D. J. POVEJSIL, R. S. RAVEN and P. WATERMAN

NEW YORK: VAN NOSTRAND. 1961. 823 PP. £6 11S. 6D.

THIS volume is intended primarily for American engineers in the guided-weapons field (it is one of a series). It deals comprehensively with system requirements, analysis and

design, with a detailed description of the system-elements and their basic characteristics. A chapter on mechanical design, environmental requirements (with direct reference to American specifications) and reliability assessment is a useful addition.

A section covering airborne Doppler navigators and weather and mapping radar is of more general interest, although the wide scope of the chapters dealing with guided-weapon system-elements makes them useful to workers in related fields. No doubt because the book is aimed at American readers, many of the numerous references are to American sources that may not be available to readers outside the United States. However, this does not detract significantly from its value. One detail criticism that might be made is of the use in such a text of the dimensions 'yards/microsecond' for the velocity of propagation of radio waves.

It is difficult to think of any aspect of airborne radar that is not fully covered in this publication, and it should prove as valuable a reference for radar engineers as did the equivalent volumes of the M.I.T. 'six-foot shelf'. B. J. O'KANE

BERECHNUNG ELEKTRISCHER MASCHINEN

W. SCHUISKY

VIENNA: SPRINGER-VERLAG. 1960. 534 PP. £9 7S.

THE title of this volume suggests that it is a work on the design of electrical machines. In this respect the title is rather misleading, for the book is actually a compendium of the author's analytical papers over the last 30 years. Around this core, the well documented work of other engineers is used to create a comprehensive review of methods evaluating many of the more detailed aspects of the performance of already designed machines.

The main text starts with a trivial description of construction, basic theory and windings of rotating machines. This could have been omitted without loss. The problems of skin-effect and additional losses in iron are treated very carefully. The discussion of leakage and steady-state and transient reactances is less complete. Transient performance of machines is well handled; and the section on the mechanical forces on windings, and on radial and axial air-gap forces, is very informative. The treatment of temperature rise with continuous and intermittent loading is based on electrical analogues.

The last 20 pages deal with the design proper of individual machines and of series of machines. It would be desirable to expand this section considerably in any new edition of the work. Design examples, or a discussion of the use of computers for design optimization, are conspicuous by their absence.

Despite the unavoidable shortcomings of the text, engineers interested in more-advanced problems of design will find it a treasure chest of information. The author, a consulting engineer, generously shares his broad experience of rotating-machine design in a lucid and interesting manner.

E. ERDÉLYI

LINEAR GRAPHS AND ELECTRICAL NETWORKS

S. SESHU and M. B. REED

READING, MASS.: ADDISON-WESLEY. 1961. 315 PP. £3 14S.

MOST engineers are familiar with some topological properties of networks, even if, like Molière's character who spoke prose, they are not always aware of it. For example, a ladder network is always minimum-phase, whereas a network with parallel paths may not be; also there is a simple relation between the numbers of loops, nodes and branches; and so on.

Although some of the fundamentals of this subject were discovered by Kirchhoff and Maxwell, they have proliferated mainly within the last decade, and this is a good time for a textbook to appear.

Topological properties can be specified in two ways: diagrammatic (linear graphs) and symbolic (matrices). The former is intuitively valuable, especially in simple cases; the latter is more amenable to manipulation in solving complete problems. Each, of course, has an established theory independent of this application.

Graph theory, with emphasis on the related matrices, takes up nearly half the text. The reader requires no previous knowledge of graphs, but he should be familiar with matrix algebra and network theory in general. The authors then give applications to network analysis, synthesis and switching theory. There is a good collection of problems, including a set of research problems whose solution would extend present knowledge considerably.

The work is clear and systematic, has a good bibliography, and can be recommended to readers with the right prior knowledge and interest. K. W. CATTERMOLE

INDUCTION HEATING

P. G. SIMPSON

McGRAW-HILL. 1960. 295 PP. £4 9S.

THE main purpose of this book is to outline a design procedure for coils, power systems and generating equipment for typical applications of induction heating. The underlying electromagnetic and heat-flow theory is discussed, and attention is paid to economic as well as technical considerations.

Induction heating is now well established as a production tool, and sufficient experience has been obtained by manufacturers and users for it to be seen in the proper perspective. Thus the author rightly advises that it should be used only where its advantages—fast heating, high power densities, accurate time and temperature control, clean operating conditions, and ease of adaptation to rapid automatic processes—can be fully realized.

This volume is a most welcome addition to the literature of the subject. It is well written and illustrated. Typical applications are described and many examples of design calculations included. There is a good index, and 99 references are listed. The chapter headings include: theory of induction heating, heat and metallurgical effects, induction-heating

applications, coil design, radio-frequency systems, machine-frequency heating systems, supply-frequency heating systems, and auxiliary and control equipment.

During the past seven years or so there has been a considerable growth in the use of mains-frequency coreless induction melting furnaces, with capacities from $\frac{1}{2}$ to 20 tons. No mention of this important development is made. Again, there is no reference to the work of L. A. Dreyfus, whose paper on high-frequency heating and temperature distribution in surface-hardening of steel, published in Sweden in 1952, is probably the most thorough treatment of the subject yet. Nevertheless, Mr. Simpson's text is strongly recommended to all engineers interested in this fascinating application of electro-heat. E. MAY

THEORY AND APPLICATION OF FERRITES

R. F. SOOHOO

NEW YORK: PRENTICE-HALL INTERNATIONAL. 1961. 280 PP. £3 3S.

THIS is a most welcome addition to the literature of ferrite development and applications, written by a physicist who has been closely in touch with that work almost from its beginnings. There is a refreshing realism about the treatment throughout the text, which strikes a very nice balance between the basic theoretical analysis and its practical counterpart.

Broadly, there are two parts to the volume: the first develops principles and points to the most important electrical and physical properties of ferrites, giving special attention to microwave-propagation characteristics; while the second concentrates more particularly on the wide variety of applications, ranging from devices that employ non-linear effects to those that exploit Faraday rotation and allied behaviour.

The book is well illustrated, and practically all the information given is supported by experimental evidence. There are three appendixes to help the reader with some of the mathematical arguments and one appendix calling special attention to some problems in the design of microwave-ferrite components. No doubt this work will be in great demand by both engineers and physicists engaged in investigations concerning the ferrites, which are perhaps the most versatile of recently developed materials. H. E. M. BARLOW

AN INTRODUCTION TO THE THEORY AND PRACTICE OF TRANSISTORS

J. R. TILLMAN and F. F. ROBERTS

PITMAN. 1961. 340 PP. £2 17S. 6D.

THE authors of this excellent treatise say that their intention was to present to the reader, within the confines of a single volume, a wide treatment of the whole subject, by selecting those parts that appeared to be of permanent value. This was an ambitious undertaking, in which they have largely succeeded.

The first 70 pages are devoted to the physical theory underlying the relevant properties of semiconductors. Although the starting-point is quite elementary, the subsequent discussion is likely to prove heavy going for any reader who is not well grounded in the elements of solid-state theory. Two further sections deal respectively with the theory of p–n junctions and transistors, and are followed by an interesting account of the technology of manufacture of semiconducting devices.

There is a good discussion of the electrical properties of diodes and transistors and of the way in which these properties are measured. In a final chapter dealing with applications, the examples are chosen rather to show the wide range of uses than to provide a comprehensive account of any of them.

There is, throughout, a praiseworthy emphasis on the relation between underlying theory and practical electrical characteristics, and the work can be recommended to anyone who wishes to understand why these new devices behave as they do. C. W. OATLEY

ELEMENTS OF MASER THEORY

A. A. VUYLSTEKE

NEW YORK: VAN NOSTRAND. 1961. 362 PP. £3 11S. 6D.

THIS text is intended to provide a comprehensive introduction to the fundamental physical theories that underly the behaviour of masers. The first half is devoted to the basic theory of quantum mechanics, statistical mechanics and the interaction of radiation and matter. The treatment starts from first principles and includes a brief account of the statistical density matrix and relaxation phenomena in quantum-mechanical systems. An axiomatic approach is adopted for the sake of brevity.

Readers who like their physics to be physical rather than mathematical may find this approach unsatisfactory. Electron spin is not mentioned in this part of the book. It is first introduced on p. 249, in the chapter on paramagnetic materials, where it appears as a rather mysterious concept that is not properly integrated into the formal development of quantum mechanics given in the earlier chapters.

The second half of the work is devoted primarily to ammonia masers and three-level paramagnetic masers. Energy levels are discussed at length. Maser action is described from the point of view of the equations of motion of the statistical density matrix. This is a sophisticated approach to maser theory, very satisfying to the specialist but requiring much enthusiasm on the part of the reader if he is to understand it.

The author has confined himself to theoretical physics and gives little attention to the engineering characteristics of masers or their applications. Expressions are derived for the gain and bandwidth of cavity masers, but travelling-wave masers are not discussed. More surprising is the relegation of the important and interesting subject of maser noise to a final chapter containing only 17 pages.

The study of masers has recently become known as 'quantum electronics'. In this volume the quantum has been amplified at the expense of the electronics. P. N. BUTCHER

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated in a footnote

ASSOCIATED ELECTRICAL INDUSTRIES (MANCHESTER) LTD.

Publication 1070–71 **Visual aids.** Manchester, 1961. n.p.

VISUAL aids to the understanding of arithmetic, algebraic and geometric relations are shown in this book, which is designed for teachers who deal with craft apprentices. College and school workshops should find no difficulty in making the devices described.

THE BOILER AVAILABILITY COMMITTEE

Testing techniques for determining the corrosive and fouling tendencies of boiler flue gases. London, 1961. n.p.

TESTING methods are divided into two main groups. First, techniques for investigating low-temperature corrosion and its causes; and, secondly, techniques for the determination of the nature and extent of high-temperature fouling. All the methods are based on the insertion of one or more probes into the gas stream.

BRITISH STANDARDS INSTITUTION

B.S. 2004: 1961 **P.V.C.-insulated cables and flexible cords for electric power and lighting.** 7s. 6d.

THIS standard gives requirements and dimensions for non-armoured p.v.c.-insulated cables for use up to 1·1kV and for p.v.c.-insulated flexible cords for use up to 440V. The cables are primarily intended for use in the conditions envisaged in the 'Regulations for the electrical equipment of buildings' published by The Institution.

B.S. 3363: 1961 **Letter symbols for light-current semiconductor devices.** 5s.

THE main use of this standard is to enable the technical characteristics of manufacturers' products to be described to their customers.

B.S. 3346: 1961 **Armoured p.v.c.-insulated cables.** 8s. 6d.

THE requirements and dimensions for wire-armoured p.v.c.-insulated cables for use up to 3·3kV are given.

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Noise in electronic devices. Chapman and Hall Ltd., London, 1961. 35s.

THE papers included in this book are based on material presented at the conference on noise in electronic devices held by the Electronics Group of The Institute of Physics in October 1959. The paper titles are 'The physical basis of noise', 'Noise in grid controlled valves', 'Noise in transistors', 'Noise in masers and parametric amplifiers', 'Current noise in fixed cracked carbon resistors' and 'The fluctuations in the characteristics of valves'.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 48 **Rules for electric traction motors.** 4th edition. Geneva, 1961. 18s.*

THE specification applies to traction motors for tramways, railways, trolleybuses and electrobuses. The 4th edition has been extended to cover compound-wound motors and motors supplied with pulsating current.

Publication 123 **Recommendations for sound level meters.** Geneva, 1961. 18s.*

RECOMMENDATIONS are made for general-purpose sound-level meters only.

INTERNATIONAL ATOMIC ENERGY AGENCY

Review series no. 9 **Comments on some aspects of nuclear power economics** by L. E. Crean, R. A. Laubenstein and L. S. Mims. Vienna, 1961. (English/French/Russian/Spanish). 6s.

THE main factors affecting the economic use of nuclear-power plants are discussed. A general survey is given of resources of hydrocarbon, carbon and radioactive fuels. Local factors that have an influence on nuclear-power programmes are considered.

NATIONAL ENGINEERING LABORATORY

Report on a visit to Japan March 14th to April 1st, 1960 by C. E. Phillips. Glasgow, 1961. n.p.

THE author gives a brief account of his visit to the 3rd international conference on non-destructive testing, of his attendance at meetings of the Standing Committee for International Co-operation in the Field of Non-Destructive Testing, of his visits to places carrying out research on metal fatigue, and of his lecture 'Studies in fatigue-crack propagation' to the Japan Society of Mechanical Engineers. In Japan, magnetic-particle methods of non-destructive testing are specified for steel components.

NATIONAL PHYSICAL LABORATORY

Notes on applied science no. 16 **Modern computing methods.** 2nd edition. H.M.S.O., London, 1961. 21s., postage 11d.

THIS is, first, a working manual for all engaged in relatively complicated computations, and secondly, a basis for courses in numerical analysis at universities and colleges of technology. The subjects covered are linear equations and matrices; latent roots and vectors of matrices; zeros of polynomials; finite-difference methods; Chebyshev series; differential equations; hyperbolic, parabolic and elliptic partial differential equations; evaluation of limits and integrals; and tabulation of mathematical functions.

U.S. DEPARTMENT OF COMMERCE: NATIONAL BUREAU OF STANDARDS

Handbook 76 **Medical X-ray protection up to three million volts.** National Bureau of Standards, Washington, 1961. 25 cents†

THE standards of safety established by sub-committee 3 of the National Committee on Radiation Protection and Measurement are set forth in this handbook.

[U.S.] NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

Publication 799 **Digest of literature on dielectrics.** Vol. 23, 1959. Washington, D.C., 1960. $8‡

THIS annual publication is divided into 12 chapters. Each chapter has an extensive bibliography. The chapter headings are 'Instrumentation and measurements', 'Tables of dielectric constants, dipole moments and dielectric relaxation times', 'Molecular and ionic interactions in dielectrics', 'Conduction phenomena in solid dielectrics', 'The breakdown of dielectrics', 'Ferroelectric and piezoelectric materials', 'Magnetic materials', 'Rubber and plastic insulation', 'Insulating films and fibrous materials', 'Insulating liquids and their applications', 'Solid inorganic insulation' and 'Applications'. The digest covers dielectrics from the point of view of the engineer as well as of the physicist and chemist. Evaluations of technical advances are made.

* Obtainable from the Sales Department, British Standards Institution, 2 Park Street, London W.1
† Obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.
‡ Obtainable from the Printing and Publishing Office, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, Washington 25, D.C., U.S.A.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

BENEDIKT, O. 621.313.236

The autodyne: a new electrical machine. **2nd, revised, edition***

London and New York: Pergamon Press, 1960. pp. 193. 23·5 × 16 cm. £2 5s.

The autodyne is a rotary amplifier with applications where motor-generators, metadynes, amplidynes, etc. are commonly used. This book was reviewed in the February 1961 *Journal*, p. 114.

GRAY, L., and GRAHAM, R. 621.396.61

Radio transmitters*

New York and London: McGraw-Hill, 1961. pp. xi, 462. 23·5 × 16cm. £4 17s.

This book covers frequency-control techniques, r.f. power amplifiers and valves, coupling circuits, modulation systems, power supplies, control and protective circuits, transmitter characteristics, measuring techniques, and hazards associated with transmitters. It was reviewed in the May 1961 *Journal*, p. 316.

HAIGH, J. D. 621.396.96

Radiolocation techniques: the Services textbook of radio—Vol. 7*

London: H.M.S.O., 1960. pp. xii, 260. 25 × 15·5cm. 15s.

This book is for technicians, but if the marked portions are omitted it is suitable for the beginner, while appendixes give mathematical proofs and analyses for the advanced reader. Direction-finding is dealt with. The fundamentals of radar transmitters, receivers, and aerials are covered, and radar direction-finding, radar displays, the various radar systems, and secondary radar are considered. Chapters discuss non-pulse radar systems, interference, and extended field navigation systems.

JERRARD, H. G., and McNEILL, D. B. 53

Theoretical and experimental physics*

London: Chapman and Hall, 1960. pp. xiv, 624. 22 × 14·5cm. £3 15s.

This book is suitable for students taking a degree in which physics is a major subject. It describes a large number of experiments in the different branches of physics—mechanics, heat, acoustics, optics and electricity—but accuracy, errors, units (including the rationalized M.K.S. system) and laboratory apparatus are first discussed.

OTHER PUBLICATIONS

ELECTRICITY COUNCIL

Trials on six power station workers' houses with electric floor-heating. Utilisation Research Report 15

London: Electricity Council, 1960. pp. 17. 28 × 21cm. n.p.

ILLUMINATING ENGINEERING SOCIETY

The I.E.S. code. Recommendations for good interior lighting 1961

London: I.E.S., 1961. pp. 60. 24·5 × 18·5cm. 12s. 6d.

Reviewed in the May 1961 *Journal*, p. 288.

LOCKHEED MISSILES AND SPACE DIVISION

Plasma acceleration edited by S. W. Kash. Fourth Lockheed symposium on magnetohydrodynamics

Stanford, California: University Press, 1960. pp. 117. 23·5 × 15·5cm. £1 14s.

[U.S.] NATIONAL ACADEMY OF SCIENCES NATIONAL RESEARCH COUNCIL

1960 annual report; conference on electrical insulation

Washington, D.C.: National Academy of Sciences—National Research Council, 1961. pp. 205. 28 × 21·5cm. £1 8s.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

The engineering industries in Europe. Statistical study by the Machinery Committee

Paris: O.E.E.C., 1961. pp. 289. 24 × 15·5cm. 10s. 6d.

SWEDISH STATE POWER BOARD

Optimum balance between water power and thermal power in the State Power System in Sweden. Blue-white series, no. 29E

Stockholm: Swedish State Power Board, 1961. pp. 20. 29·5 × 20·5cm. n.p.

TELECOMMUNICATIONS ENGINEERING ESTABLISHMENT

THE new buildings of the Telecommunications Engineering Establishment at Gatwick, Surrey, recently opened, consist of an office, a workshop block and a radar experimental building. The T.E.E. is the latest of the British Ministry of Aviation's establishments, having been formed on the 1st May 1959.

The T.E.E. is concerned with the field engineering of safety services: it is not directly concerned with research and development. Installation programmes and the major overhaul of equipment to prolong its useful life and to sustain its performance to the necessary standards are the responsibility of the T.E.E. Models, prototypes and small specialized parts are made at Gatwick. The T.E.E. provides an immediate major-repair service for civil-aviation ground installations throughout the United Kingdom, and is concerned with system engineering where diverse equipments have to be integrated to meet the needs of such organizations as air-traffic control, aviation police, meteorological services, etc.

The new T.E.E. building at Gatwick Airport

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 7TH JULY 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	930	9722	2	1
£2 to <£5	2386	6591	8	10
under £2	31623	16667	4	0
		48846	17	11

APPOINTMENT AND NOMINATIONS

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

ON the nomination of the Ministry of Transport, the Council of The Institution have appointed Mr. W. Young to succeed Mr. G. Burdon, B.SC., on the above committee.

B.S.I. CODE DRAFTING COMMITTEE ELCP/17—EARTHING

The Council have nominated Mr. T. W. Wilcox, MEMBER, to serve as their representative on the above committee in place of the late Mr. P. B. Frost, MEMBER.

B.S.I. TECHNICAL COMMITTEE ELE/82—DOMESTIC AND SIMILAR ELECTRICAL APPLIANCES AND ACCESSORIES

The Council have nominated Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, to serve as their representative on the above committee, for liaison with the Wiring Regulations Committee, in place of Mr. S. L. M. Barlow, MEMBER, who has resigned.

AWARD OF PREMIUMS

THE Council of The Institution have awarded the following premiums for papers read or accepted for publication during 1960:

GROUP A

The Institution Premium (value £50)
No award

The Kelvin Premium (value £25)

Prof. F. C. Williams, O.B.E., D.SC., D.PHIL., F.R.S., E. R. Laithwaite, M.SC., PH.D., J. F. Eastham, M.SC., and L. S. Piggott, M.SC.(ENG.)	'The logmotor—a cylindrical brushless variable-speed induction motor'
Prof. F. C. Williams, O.B.E., D.SC., D.PHIL., F.R.S., E. R. Laithwaite, M.SC., PH.D., J. F. Eastham, M.SC., and W. Farrer, M.SC.	'Brushless variable-speed induction motors using phase-shift control'

The John Hopkinson Premium (value £25)

F. Kift	'The propagation of high-frequency radio waves to long distances'

GROUP B

Electronics and Communications Section Premiums

The Duddell Premium (value £20)
No award

The Ambrose Fleming Premium (value £15)

R. F. Cleaver, M.SC.(ENG.), P. Sothcott, B.SC., and Group-Capt. F. J. Robinson, O.B.E., D.F.C.	'An automatic radio triangulation system'

Premiums (value £10 each)

P. J. B. Clarricoats, B.SC.(ENG.), PH.D.	'Propagation along unbounded and bounded dielectric rods. Part 1—Propagation along an unbounded dielectric rod; Part 2—Propagation along a dielectric rod contained in a circular waveguide'
G. V. Geiger, B.SC., N. D. La Frenais, B.SC.(ENG.), and W. J. Lucas, M.SC.	'Propagation measurements at 3480 and 9640 Mc/s beyond the radio horizon'
W. Hersch, PH.D., B.SC.(ENG.)	'The surface-wave aerial'
L. R. F. Harris, M.A., V. E. Mann and P. W. Ward, B.SC.(ENG.)	'The Highgate Wood experimental electronic telephone exchange system'
R. G. Knight, B.SC.(ENG.), A. D. Martin, E. A. R. Peddle, B.SC., and B. D. Simmons	'System operation of a t.d.m. switched-highways electronic telephone exchange'
H. H. Adelaar and A. Salle	'Programme-controlled logical systems in electronic telephone exchanges'
H. H. Adelaar, F. A. Clemens and J. Masure	'Outlines of a t.d.m. two-wire telephone switching system and its control'
J. van Goethem	'The capacitive semi-permanent information store and its uses in telephone exchanges'
S. Cornbleet, B.SC.	'A new design method for phase-corrected reflectors at microwave frequencies'

Measurement and Control Section Premiums

The Silvanus Thompson Premium (value £20)
No award

The Mather Premium (value £15)

B. J. Davies, B.SC.(ENG.), R. C. Robbins, B.A., C. Wallis, B.SC., and R. W. Wilde, B.SC.	'A high-resolution measuring system using coarse optical gratings'

Premiums (value £10 each)

E. H. Cooke-Yarborough, M.A., and R. C. M. Barnes, B.SC.(ENG.)	'Rapid methods for ascertaining whether the activity of a weak radioactive sample exceeds a predetermined level'
R. M. Huey, B.SC., B.E., O. Pawloff, DIPL.-ING., and T. Glucharoff, DIPL.-ING., M.E.	'Extension of the dual-input describing-function technique to systems containing reactive non-linearity'
Prof. T. Kilburn, M.A., D.SC., PH.D., D. B. G. Edwards, PH.D., M.SC., and D. Aspinall, M.SC.	'A parallel arithmetic unit using a saturated-transistor fast-carry circuit'
L. R. Blake, PH.D., B.SC.	'Resistivity monitor to indicate oxide content of sodium'

For the following series of papers published over a number of years:

J. L. Douce, PH.D.	'A note on the evaluation of the response of a non-linear element to sinusoidal and random signals'
J. L. Douce, PH.D., and J. C. West, PH.D.	'A magnetic-drum store for analogue computing'
J. L. Douce, PH.D., M.SC., and R. E. King, M.SC.	'The effect of an additional non-linearity on the performance of torque-limited control systems subjected to random inputs'
Prof. J. C. West, PH.D., D.SC., J. L. Douce, PH.D., M.SC., and B. G. Leary, B.E.	'Frequency spectrum distortion of random signals in non-linear feedback systems'

Announcements to members (continued)

Supply Section Premiums

The Sebastian de Ferranti Premium (value £20)

L. Gosland, B.SC., and R. G. Parr, B.SC.(ENG.)	'A basis for short-circuit ratings for paper-insulated cables up to 11kV'
G. S. Buckingham, B.SC.(ENG.)	'Short-circuit ratings for mains cables'

The John Snell Premium (value £15)

E. C. Rogers, M.SC., and D. J. Skipper, B.SC.(ENG.)	'Gaseous discharge phenomena in high-voltage d.c. cable dielectrics'

Premium (value £10)

E. H. Cox and R. E. Martin, D.F.H.	'Radiocommunication in the power industry'

Utilization Section Premiums

The Crompton Premium (value £20)

W. R. Stevens, B.SC., and H. M. Ferguson	'A survey of street lighting and its future'

The Swan Premium (value £15)

K. F. Bacon	'Transistorized regulation and control of aircraft electrical power systems'

Premium (value £10)

J. P. McBreen	'Some considerations in the application of power rectifiers and convertors'

Non-Section Premiums

The Ayrton Premium (value £20)
No award

The Llewellyn B. Atkinson Premium (value £15)
No award

GROUP C

The Blumlein–Browne–Willans Premium (value £20)
No award

The Frank Gill Premium (value £15)

R. L. Grimsdale, M.SC., PH.D., and P. H. Sinclare, M.SC.	'The design of housing-estate distribution systems using a digital computer'

The Heaviside Premium (value £15)

R. G. Medhurst, B.SC.	'Explicit form of f.m. distortion products with white-noise modulation' 'Fundamental and harmonic distortion of waves frequency-modulated with a single tone' 'R.F. spectra of waves frequency-modulated with white noise'

Oversea Premiums

For senior members (value £15)

D. Broadbent, B.SC., M.ENG.SC., PH.D., and K. N. Stanton, B.E.	'An analytical review of power-system frequency, time and tie-line control'

For Students and Graduates under 28 years of age (value £10)
No award

The Coopers Hill War Memorial Prize and Medal (value approximately £20)
(Founded by the members of the Royal Indian Engineering College, Coopers Hill, in commemoration of members of the college who fell during the 1914–18 War, and awarded annually by The Institution of Civil Engineers and triennially in turn by The Institution of Electrical Engineers, the School of Military Engineering, Chatham, and the School of Forestry, Oxford. The Prize is for the best paper on a professional subject published by The Institution during each three-year period; only Corporate members under 35 are eligible.)

A. E. Karbowiak, PH.D., B.SC.(ENG.)	'Microwave aspects of waveguides for long-distance transmission'

Graduate and Student Premiums

Premiums (value £10 each)

K. I. Bartlett, B.SC.(ENG.)	'Servos for trainable mountings with special relation to the Bloodhound launcher'
J. D. Edwards	'Stereophony on disc'
A. C. Hall	'The design of power transformers by digital computer'

The Henry Nimmo Premium (value £10)

R. Hawley, B.SC.	'Magnetohydrodynamic power generation'

Premiums (value £5 each)

P. J. Bennett	'Noise, with particular reference to transformers'
J. B. Edwards, B.SC.(ENG.)	'Electromagnetic forces on busbars'
R. E. Hayes, M.SC., PH.D.	'Electrical phenomena at very low temperatures'
P. Richardson, B.SC.	'The mercury-arc convertor and its applications'
T. J. Roberts, B.SC.	'Heat flow in rotating electrical machines'
K. von Krogh	'Brain waves'

Letters of Commendation

K. W. Huddart, B.A.	'Power from the atom'
K. S. Millington	'Photoelectric cells and some of their industrial applications'
E. J. Waddon	'Plastic telephone cables' 'Interference between communication and power circuits'

THE INSTITUTION STAFF: EDITORIAL VACANCY

THERE is a vacancy for an Editorial Assistant for work on the *Proceedings* of The Institution. The qualifications required are an engineering or science degree with some engineering experience, and the ability to edit high-class technical copy. Applicants should be about 30 years of age. The salary would depend on qualifications and experience. Entry to a Staff Pension Fund would follow a short period of service. Those who are interested should write to the Secretary, The Institution of Electrical Engineers, Savoy Place, London W.C.2, giving full particulars of their education, training and experience.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

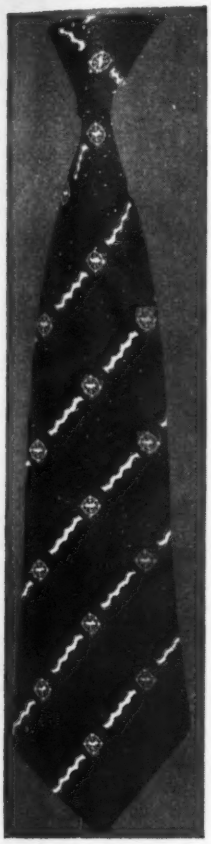
MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address, the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested when notifying a change of address to give their full initials, their previous address and their class of membership.

MEMBERSHIP OF LOCAL CENTRES AND SUB-CENTRES

A MEMBER whose registered address is within the area of a Centre or Sub-Centre is automatically attached to the Centre or Sub-Centre concerned and also, if he is a Student or a Graduate under the age of 28, to any Graduate and Student Section within the area. Any member who so wishes, however, may be attached to any Centre or Sub-Centre adjacent to that in which he resides, if this is more convenient to him, by making a request in writing to the Secretary of The Institution.

THE INSTITUTION TIE



SUPPLIES of the Institution tie and of a square (30 × 30in.) of the same design can be obtained on application to the Secretary of The Institution. The charges, which are as follows, are intentionally kept low, but any profit is allowed to accumulate and is then transferred to the Incorporated Benevolent Fund.

Ties:

silk (heavy quality)	£1 3s. 6d.
Terylene	18s. 0d.

Square:

Terylene	£2 2s. 0d.

The general appearance of the tie may be seen from the accompanying illustration.

A wavy gold line edged in red, running diagonally across the navy-blue background of the tie, represents wave motion, one of the fundamental concepts of electrical engineering that appear on The Institution's coat of arms.

A shield of light blue—by common consent the predominantly 'electrical' colour—shows a winged golden thunderbolt enclosed in a golden ring bearing golden fleurs-de-lis at the four cardinal points. This alludes to the power of electricity circumscribed and under control; the fleurs-de-lis on the encircling ring make a passing reference to the compass card and thus to our seal and to the work of Kelvin.

COLOUR TELEVISION

A REFRESHER course of six lectures on colour television, organized by the Television Society, will be given on the six consecutive Monday evenings between the 18th September and 23rd October 1961 in the large lecture theatre at the London School of Hygiene and Tropical Medicine.

Enrolment forms are obtainable from the Television Society, 166 Shaftesbury Avenue, London W.C.2.

LECTURES ON ARBITRATION

A SERIES of lectures on arbitration has been arranged by the Institute of Arbitrators. They will all be held at 6 p.m. at the Royal Institute of British Architects, 66 Portland Place, London W.1. The programme is primarily intended for members and students of the principal professional bodies, in collaboration with which the lectures have been arranged.

The first lecture, on arbitration agreement, will be given on the 10th October 1961 by J. R. W. Alexander and will deal with the nature of arbitration, the Arbitration Act 1950, and arbitration agreement. The second lecture, by A. B. Waters, will be delivered on the 17th October and will deal with dispute—the arbitrator, the umpire and the expert witness. Preliminary proceedings are the subject of the third lecture on the 24th October by Lord Meston, covering pleadings, evidence, case stated and the High Court. The fourth lecture will consider hearing and award, including costs, appeal, and enforcement, and will be given on the 31st October by J. R. W. Alexander.

Further information is available from the Institute of Arbitrators, 27 Regent Street, London S.W.1.

CORRECTION

BY a misprint, the expenditure total on p. 423 of the July 1961 *Journal* was shown as £238,5335. This should, of course, be £238,533.

NON-LINEAR MAGNETICS

A CONFERENCE on non-linear magnetics will take place from the 6th to 8th November 1961 at the Statler Hilton Hotel, Los Angeles, California. The meeting is being sponsored by the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further details can be obtained from Dr. T. Bernstein, Space Technology Laboratories, P.O. Box 95001, Los Angeles 45, California, U.S.A.

RELIABILITY AND QUALITY CONTROL

A SYMPOSIUM on reliability and quality control will be held at the Statler Hilton Hotel, Washington, D.C., U.S.A., from the 9th to 11th January 1962. The symposium is sponsored by the Institute of Radio Engineers, the Electronics Industries Association, the American Institute of Electrical Engineers, and the American Society for Quality Control.

R.E.M.E.

AT The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1, on the 4th April 1962 at 6 p.m., Maj.-Gen. D. A. K. Redman, O.B.E., B.SC.(ENG.), R.E.M.E., ASSOCIATE MEMBER, will deliver a nominated lecture on 'The Corps of Royal Electrical and Mechanical Engineers—its responsibilities and problems'.

Members of this Institution are invited to attend.

Forthcoming Institution events

THE nature of the meeting is indicated by the following key:

E ELECTRONICS AND COMMUNICATIONS SECTION
S SUPPLY SECTION

September 1961

E **6–8** *Wednesday–Friday* Conference on microwave measurement techniques (at Savoy Place) (all wishing to attend are required to register; forms are available on application to the Secretary of The Institution) (see p. 503)

S **6–9** *Wednesday–Saturday* Supply Section visit to Dinard

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL, AND ELECTRONICS AND COMMUNICATIONS

PRECISION MEASUREMENT AT HIGH FREQUENCIES

A JOINT meeting of the Measurement and Control, and Electronics and Communications Sections was held at Savoy Place on the 11th April 1961 with Mr. C. G. Garton in the Chair. Mr. D. Woods delivered a very impressive lecture 'Precision instruments for coaxial line measurements up to 4Gc/s', the lecture being supported by his paper 'The concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration'. A short review of this paper appears on p. 515.

Absence of national r.f. standards

Mr. Woods referred to the difficulties experienced during the 1939–45 War owing to the absence of national r.f. standards. Standards were set up locally but differed between localities, and it became clear that there was a definite need for national standards with provision for international comparisons. Such standards would eliminate the possibility of dispute over the performance of measuring instruments for the home and export markets.

A programme was initiated in 1948 to improve the accuracy of standardization and measurement of admittance, voltage, power and attenuation for frequencies up to 4Gc/s in relation to coaxial systems. It was necessary to develop a range of wide-band instruments of such good voltage standing-wave ratios (v.s.w.r.) that the effect of mismatch could be substantially ignored. Particular attention had to be given to the problems of coaxial connectors, and new ones were developed with a v.s.w.r. of 0·99.

Mr. Woods discussed the remarkable precision dual-admittance bridge he developed some years ago to cover the range 3–300Mc/s with an accuracy within 0·1–0·2%. Engineering tolerances of 0·0001in. were necessary in the construction of this bridge. This bridge was a major advance in technique. He described a wide range of precision r.f. measuring instruments, using lantern slides to illustrate the more important features. He paid particular attention to the theory of the tractorial resistor as a power-absorbing and terminating device.

Many of the instruments described were on show, and collectively they formed a fine exhibition of the art of the instrument maker.

High-grade plumbing

Dr. John Brown opened the discussion by pointing out that the work of Mr. Woods and his colleagues had resulted in an improvement in accuracy of measurement of an order of magnitude over the frequency range considered. Although this range was below that for waveguides, where plumbing techniques were used, the new designs stemmed from experience in the waveguide field, and it was clear that Mr. Woods was basically a very-high-grade plumber. He suggested that directional couplers could be developed for impedance measurement as an alternative to the bridge. He explained that the term 'precision measurement' had a special meaning in the microwave region, being given to a particular class of measurement techniques and not interpreted in terms of percentage error.

Mr. L. Lewin expressed some surprise at the linear dimensions being expressed in inches for devices that were intended to be international standards. He commented on the difficulties of designing coaxial systems with a minimum of dielectric support material and asked whether the butt joints used in these instruments would not be a source of trouble. A number of other speakers asked questions on matters of design detail, means of obtaining variable standards for impedance measurement were discussed, and Mr. Woods was specifically asked what improvement in performance was obtained with his new connectors.

Unresolved difficulties

Mr. Woods replied individually and at some length to the speakers. He thought that there were as yet too many unresolved difficulties to permit the use of directional couplers for impedance measurement. The v.s.w.r. of the new connectors was 0·999, which was 40 times better than that of previous types. The choice of linear dimensions was governed by the availability of precision-drawn tube; nevertheless, some of the dimensions had been adopted by the United States. No contact troubles had been experienced with the butt joints; the faces were machined to 0·0001in. and were held together under heavy pressure.

Mr. Woods explained that, although satisfactory admittance bridges could be made, impedance bridges were much more difficult because of the impossibility of constructing a variable resistor that would work in the frequency range considered.

Mr. H. Stanesby, in moving the vote of thanks, said that it was the underground spade-work wot dug the 'ole; measurement was the underground spade-work, and the difficulty of this work was not generally appreciated by the electronics engineer. He congratulated Mr. Woods on a really magnificent lecture.

F. C. W.

EVAPORATED FILMS

THE Measurement and Control, and Electronics and Communications Sections joined together for two lectures on the formation and use of thin films on the 2nd May 1961 at Savoy Place. Mr. C. G. Garton was in the Chair. Dr. D. W. Pashley lectured on 'Structural properties and applications of evaporated metal films'. He first considered the effect of the surface on which the film was formed. Where this substrate was amorphous, the coating was crystalline; but where the substrate was already crystalline (e.g. rock salt), the film could sometimes grow in the form of a thin single crystal.

He described, with the aid of slides, the growth of the gold film on rock salt at 300°C. The deposit first occurred as discrete particles. When the film was an average of 10Å thick, these small dots could be seen to form along surface defects such as dislocations. By the time it was 30Å thick, the particles began to merge until, at 200Å thickness, they were few but large. At a thickness of 500Å, the surface was mainly covered with film, but there were still insulating channels about 30Å wide breaking it into large islands. By a thickness of 700Å, the film was complete but showed surface defects from the crystal.

Low interfacial energy

If a thin conducting film was required, it was necessary to choose a surface–film combination having a low interfacial energy. For example, gold could be applied to silver, which had a similar crystal lattice. With this combination, at 10Å thickness the film formed as a few big units that joined when 40Å thick to form a lace-like pattern. By a thickness of 50Å, the film had only a few holes; and by a thickness of 100Å, it was free from defects.

A practical application occurred in coating a windscreen with a conductive film of gold. Applied directly to the glass, the gold film would require to be so thick as to be opaque before it would be of suitable resistance. If the glass was first sputtered with bismuth oxide to form a suitable base, the gold film had an 80% optical transparency, with the normal bulk resistivity of gold.

These thin films were often stressed beyond the bulk yield stress of the material (e.g. a thin sheet of mica could be buckled by a coated film). Electron-diffraction experiments confirmed the presence of this stress, and in the United States further indication had been obtained by coating a gold film on rock salt and then drilling a 1 mm hole through the rock salt to the gold. The gold film sagged over the hole, indicating a 0·4% compressive strain.

Dr. Pashley showed an interesting cine film that he had taken by growing the metal film in an electron microscope, which was used to show the growth of the particles. Silver was deposited on a molybdenum sulphide substrate at 300°C. A cine camera took eight pictures per second of the fluorescent screen. The film showed the growth of the silver from small spots to complete coverage and gave the impression of watching a horizontal sheet of glass in a shower of rain. The spots were very mobile, and when they touched each other they contracted together to form larger spots.

Practical applications

Mr. J. R. Balmer's lecture was entitled 'Deposition of evaporated non-metallic films'. He spoke on the practical application of non-metallic films that could be used for lens blooming, interference filters and capacitor dielectrics. Two methods were available. Vacuum evaporation at pressures of the order of 10^{-4} mm Hg could be accomplished using either resistive heating if the material could evaporate without wasting the crucible, or electron bombardment to heat insulating materials. Reactive sputtering was the alternative at pressures of about 0·1 mm Hg in an atmosphere of oxygen or argon. This process was slower than vacuum evaporation and more unpredictable in volume distribution, but it was used for films that would decompose in the vacuum. Thus tantalum oxide could be formed conveniently by sputtering tantalum in an oxygen atmosphere.

He went on to describe the various methods of controlling the process and considered its applications to the construction of miniature capacitors. Barium titanate had been deposited with a dielectric constant of 1000 and gave capacitances of $1\,\mu F/cm^2$. Surface stresses had been found to be both compressive and tensile in various conditions of depositing. It was essential to have a dry atmosphere during the complete construction of the capacitor to prevent low leakage resistance. He looked forward to multi-layer capacitors of several hundred microfarads per cubic centimetre and to high-temperature capacitors working at 250°C using silicon oxide dielectrics.

Question time

Questions ranged over both applications and film formation. Mr. A. A. New had constructed silicon oxide capacitors of $0{\cdot}02\,\mu F/cm^2$, working at 10–15 V; $600\,\mu F/cm^2$ could be expected, but if barium titanate were used even better values could be obtained. Although shelf-lives of four years had been achieved, cases had occurred where the metal films developed cracks, increasing losses. When challenged on cost, Mr. Balmer replied that it was economic to evaporate aluminium on to car-headlamp reflectors. He looked forward to building circuits *in situ* by evaporation.

Mr. Hayes said that a colleague had been depositing films side by side, measuring the resistance of one film as an indication of thickness. He had found that the film being measured might be 20Ω while an 'identical' neighbour might have infinite resistance. He ascribed this to the removal of electrostatic charge and suggested this was why gold evaporated well on to silver; Dr. Pashley did not know of this effect, but did know that copper evaporated on to silver in islands, although gold formed a thin film. Another member had noticed a similarity between Dr. Pashley's film and observations he had made in aqueous electrodepositing.

Dr. Pashley agreed with a further suggestion that it was necessary to keep the substrate heated in his electron microscope to prevent oil vapour condensing on to it. Questioned on depositing alloy films, he replied that, if constituents had very different vapour pressures, it might be necessary to have separate sources for each, with controlled temperatures to give the proper proportions. Alternatively, it was possible sometimes to deposit constituents as separate layers and then use heat to diffuse them. Mr. Balmer answered a question on capacitors by stating that continuous films of insulating material 300Å thick had adequately prevented opposing metal films from making contact.

The members who attended this meeting went away feeling they had a clear picture of some of the problems involved in the apparently simple process of evaporating thin films.

W. H. P. L.

News from the Centres

SOUTHERN CENTRE

Faraday and Hunter

DEPARTING from past custom in the Centre, the Faraday Lecture was presented at Portsmouth instead of at Southampton on the 14th February 1961.

The excellence of Mr. L. J. Davies's address on 'Transistors and all that' was endorsed by an attendance of 4000 people—a full house at each of two sessions in the elegant Portsmouth Guildhall.

We were also fortunate in having Dr. J. S. Forrest's visit on the 5th April 1961 to give the Third Hunter Memorial Lecture, 'The application of electronics to the electricity supply industry', at Portsmouth. Among the many 'visual aids' one was immediately struck by the effectiveness of closed-circuit television as a method of showing miniature components to a lecture-hall audience. The author's opening theme, namely the rate of advance in design of electronic devices in contrast to that of power-frequency equipment, was supported by novel demonstrations. In proposing a vote of thanks after the Lecture, the Immediate Past-Chairman, Mr. W. D. Mallinson, referred to the happy marriage of power and light-current interests—a topical point in the development of the Centre.

An article based on the Lecture appeared in the May 1961 *Journal*, p. 289.

Dinner and Dance

The date of the Annual Dinner and Dance—the 7th April 1961—at Brighton was rather close to the Easter holiday, otherwise the attendance figure of 165 might have exceeded instead of merely equalling that for last year. The principal guests were Mr. O. W. Humphreys, a Vice-President, and Dr. G. E. Watts, Principal of Brighton Technical College. A plaque in the banqueting-room of the Old Ship Hotel, commemorating the fact that Paganini played there in 1832, enabled Dr. Watts in his speech to link the significance of Faraday's achievements in that year with the presence of this gathering of professional engineers. Dancing continued until 1 a.m., and members and their ladies appeared to enjoy a happy evening.

At the Dinner and Dance at Brighton on the 7th April 1961

Standing (left to right): Mr. L. H. Fuller, Dr. G. E. Watts, Messrs. O. W. Humphreys, R. Goford (Chairman), W. D. Mallinson and H. W. Housley

Seated (left to right): Mesdames Fuller, Mallinson and Housley

Summer Meeting

The Centre's Summer Meeting took place on the 27th May. A party of about 30 from the Portsmouth and Southampton area set out by coach to Brighton, there joining some 20 local members for a tour of Allen West's factory. The new proving plant, equipped for testing control gear at infeeds up to 25 MVA, provided plenty of interest. Facilities for endurance testing, for shock and vibration tests and for accurate measurement were enhanced by modern design and lay-out.

After lunch, kindly provided by Allen West's, technology gave way to the charm of one of England's stately gardens at Leonardslee, near Horsham. The season was right for the famous and extensive display of rhododendrons and azaleas, among which members of the party were able to stroll until

At Allen West's on the 27th May 1961

The party starting a tour under the guidance of Mr. S. H. Harding, Sales Manager (extreme left, with lapel badge)

the time for the coach to leave for Midhurst. Thence after supper the contingents left for their home towns at the conclusion of a long and varied day. J. L. H.

Golf competition and raffle

Golfers are frequently conscious of the unwarranted mischances that befall their own worthy efforts and of the good fortune that their friends and opponents enjoy. One thing quite free from reasonable criticism was the weather enjoyed by 34 golfers on the Brockenhurst Manor golf course at Brockenhurst in the New Forest on the 6th June 1961. The course was dry and called for extreme care in approaching and putting. In consequence, scores were not as good as in most previous years, but as a social occasion the day lived up to all previous standards.

A charming innovation was to receive our first lady entrant in the singles golf competition, Mrs. G. A. V. Sowter. Dr. Sowter also played. It would be an added interest to 'the day' if other ladies could be persuaded to join us in future years.

The Pirelli-General Cup for singles handicap play was won by Mr. P. J. Warhurst (on his first entry).

The Coates Cup for four-ball better-ball bogey play was won for the second time by Messrs. R. G. Farrell and A. W. Hunt. Other prizes were won by Messrs. P. S. Spring, R. F. Arnold, M. R. G. Paice and S. W. Owen.

The Benevolent Fund will benefit by £66 as a result of the day, largely from the proceeds of the raffle that accompanied the golf competitions. J. E. B.

Hull District

Two meetings were held in 1960 at the Yorkshire Electricity Board offices, Ferensway, Hull. The Convener welcomed three speakers, Messrs. H. Anderson, C. H. Nicholson and A. Minty, on the 20th October, when they presented a symposium of papers on 'Earthing'. Mr. Anderson dealt with the supply authorities' problems, Mr. Minty discussed users' problems, and Mr. Nicholson spoke as a consultant. The papers attracted much interest and resulted in a record attendance of over 120 members and guests.

The second meeting, on the 1st December, was a joint one with the Students and Graduates. Mr. E. G. Robinson read his paper 'Marine electrical practice on cargo liners'.

Faraday Lecture

The Faraday Lecture was given in Leeds Town Hall on the 26th January 1961 before a packed audience of about 1250 persons. The popularity of the Lecture was indicated by the large number of applications for tickets that had to be regretfully refused.

The title of the Lecture, 'Transistors and all that', caught the imagination. It was presented by Mr. L. J. Davies almost without notes and with a wealth of absorbing experiments and demonstrations. We had no knowledge of the passing of time and were sorry when the Lecture came to an end.

Proposing a vote of thanks, Mr. C. G. Richards expressed our pleasure and thanks to the author and his assistants and congratulated them on the ingenuity of the demonstrations and the precision with which they had been carried out.

Hunter Memorial Lecture

We were indebted to Leeds University for the use of the fine new Houldsworth Hall Lecture Room when Dr. J. S. Forrest delivered the Hunter Memorial Lecture 'Electronics in the supply industry' on the 8th February 1961 before an audience of 150 members and guests. Dr. Forrest said how happy he felt P. V. Hunter would have been to have had the facilities of transistors and similar equipment available to him in his work. Dr. Forrest went on to draw a comparison between the rate of growth of the supply industry and the rate of growth in the use of transistors. His survey of the use of electronics was enlightening to everyone present, and their understanding was greatly enhanced by the many interesting demonstrations. An article based on the Lecture appeared in the May 1961 *Journal*, p. 289.

In proposing a vote of thanks, Mr. W. J. A. Painter said it was a source of pride and pleasure to listen to a lecture by such an eminent member of The Institution and to one who had contributed so much to our knowledge through his many papers.

Catterick District

Dr. F. A. Benson read his paper 'Developments in lighting' to an enthralled audience at the School of Signals on the

14th March 1961. He started with a historical introduction which rapidly brought the audience to the age of bamboo shoots and carbon-filament lamps.

With the aid of a large array of apparatus, he showed the development of lamps for the home, the street and the display window. He then picked his way most ably through the tangled growth of luminescence, fluorescence and electro-luminescence, while his assistant, Mr. P. G. Ridsdale, painted himself with Vaseline and glared in a very convincing manner reminiscent of voodooism and the rituals of the Central Amazon jungle.

This was a most excellent and lucid lecture that everyone thoroughly enjoyed.

Air photography and history

It has become the custom, following the formal business of the Annual General Meeting, to hear a lecture on a non-electrical subject. On this occasion the meeting was addressed by Prof. M. W. Beresford of Leeds University at the Leeds and County Conservative Club on the 2nd May 1961. His subject was 'Air photography and history'. The lecture was illustrated by a large number of slides and proved to be of absorbing interest.

The effect of buried buildings on the growth of crops or other vegetation allowed ancient villages and road systems to be clearly traced on the slides.

A vote of thanks was proposed by the Chairman-elect, Mr. W. J. A. Painter, and supported with acclamation. A collection on behalf of the Benevolent Fund realized a sum of over £17.

Golf at Sandmoor

The Annual Golf Competition on behalf of the Benevolent Fund was held at Sandmoor Golf Club on the 16th May 1961, when over 80 members and guests played. It was an ideal day for golf, and with the course in perfect condition everyone thoroughly enjoyed himself. The dinner following the tournament was presided over by the Centre Chairman, Mr. F. W. Fletcher, who took the opportunity to thank the Club for the excellence of their arrangements and the most enjoyable meal. The evening ended with the presentation of prizes and the usual auction on behalf of the Benevolent Fund.

H. H.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Power-system analysis

When Dr. J. R. Mortlock visited Brisbane in the earlier part of 1961, the Committee arranged for him to give a lecture on 'Power-system analysis'. Invitations to the lecture were issued to The Institution of Engineers, Australia, to members of the electrical industries and to the three supply authorities, the last-mentioned group having a particular interest in the topic.

Dr. Mortlock spoke of the complexity of the subject of power-system growth, of the many variables to be taken into consideration, and of the need for planning up to 20 years ahead. He warned against placing implicit trust in specific factors related to the many variables and emphasized the importance of local knowledge in appreciation of the problem of development in a particular area.

Physical plasma

During May 1961 our members received an invitation from the Engineering Department of the University of Queensland to attend a lecture by Dr. A. von Engels on 'Physical plasma in application to the direct generation of electricity'. This proved to be most informative. Dr. von Engels described, in some detail, the relatively simple apparatus used in some experimental work on the subject and developed a formula that agreed closely with the results achieved. Prof. Prentice moved a vote of thanks to the speaker which was carried by acclamation.

W. I. G.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th May to 15th July 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

ADAMS, R. M. J. (Salisbury, S. Rhodesia)
ASARE, J. K. (Accra)
BAKER, A. G. (Lagos)
BINDOFF, L. L. (Cape Province, S. Africa)
BOON, H. V. (Geneva)
BRADBURY, J. J. C. (Nassau, Bahamas)
CARRUTHERS, P. O. (Calcutta)
CHANDRASINGHE, D. P. (Colombo)
COLEMAN, W. F. (Bombay)
COOPER, B. C. J. (Kuala Lumpur)
CRAWSHAW, W. (Salisbury, S. Rhodesia)
CUTHERBERT, G. T. (Melbourne)
FOWKES, F. K. (Bathurst, Gambia)
FRY, T. C. (Perth, W. Australia)
GIDDY, J. H. (Melbourne)
GRIFFIN, R. C. (Toronto)
GUEVARA, E. J. (Trinidad)
HALLIGEY, F. J. (Vereeniging, Transvaal)
HARMER, L. B. (Hamilton, Bermuda)
HARRISON, H. C. (Melbourne)
HIRST, J. B. (Kampala, Uganda)
HUSSAIN, L. E. (Lahore, W. Pakistan)
IGIEHON, H. I. (Nigeria)
LANGLEY, G. A. (Kuala Lumpur)
LICENCE, F. G. (Durban)
LONG, R. P. (Jerusalem)
MARSHALL, H. F. (Melbourne)
MEADE, J. (Frankfurt)
MILLS, J. J. (Hedjuff, Aden)
MUIR, D. K. (Sydney)
PARKER, P. D. (Malta)
PICKEN, G. H. (Malacca, Malaya)
QUARTEY, E. L. (Accra)
ROBERTS, L. F. (Hong Kong)
SAJNANI, N. B. (Bombay)
SEN GUPTA, N. N. (Calcutta)
SHROFF, A. K. (Madras)
SKINNER, R. G. C. (Khartoum)
SLOANE, R. W. (Beirut)
SMITH, D. H. (Lagos)
STEWART, C. E. (Bombay)
TAMIR, Y. (Haifa)
TURNER, J. (Bulawayo, S. Rhodesia)
WALDEN, H. (Trinidad)
WATT, A. M. (Vereeniging, Transvaal)
WHETTON, D. S. (Salisbury, S. Rhodesia)
WILSON, G. L. (Pennsylvania, U.S.A.)